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J. F. KELLY, *Editor*

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IRON AND STEEL EXPOSITION

CLEVELAND AUDITORIUM - CLEVELAND, OHIO

JUNE 15th - 19th, 1931

The Iron and Steel Exposition is an institution that is fostered, sponsored, owned and controlled by the only engineering organization in the United States whose activities are exclusively devoted to the problems of the Iron and Steel Industry.

The Iron and Steel Exposition is just ONE of the activities of the ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS. It is, however, one of its valuable functions, and it assists in rounding out the operating cycle of this Society.

During the year this Society conducts technical sessions in all the leading Steel centers of the United States; discussing the operating and maintenance problems that confronts our vast Industry. All this data is then compiled, edited by the Executives of the Industry and distributed throughout the Steel World through their official medium, the IRON AND STEEL ENGINEER. This periodical, a monthly paper, acts as a clearing house for the problems of this Industry.

Another important function of the Association are the Inspection Trips. Inspection Trips are made to the various Iron and Steel Plants to inspect and examine the most modern and up-to-date equipment and methods in service.

Once a year the Manufacturers who service the Iron and Steel Industry are presented an opportunity to display or exhibit the new developments in their products and equipment to the buyers and operators who are the men who will in the final analysis be responsible for the selection, installation, operation and maintenance of millions of dollars worth of equipment purchased by our Industry, annually.

The attendance at the Iron and Steel Exposition is confined principally to the Iron and Steel Industry and represents a purchasing power which means millions of dollars each year. The attendance is almost hand-picked, it represents executive and engineering talent of the Steel Making Art. The results that are to be obtained in the Iron and Steel Exposition are evidenced by the fact that the largest manufacturers of equipment in the world are with us each year.

It will be readily seen and appreciated that the Iron and Steel Exposition has its place; that it has a true function and co-ordinates with the balance of the activities of an Engineering Society. Manufacturers should keep in mind that the contacts made at the Iron and Steel Exposition may be continually renewed through the many various activities of the A. I. & S. E. E. during the year.

EDITORIAL

To the Membership of the A. I. & S. E. E., Engineering Executives and Operating Superintendents of the Iron and Steel Industry:

In about sixty days the Convention and Exposition of our Association will be in session—June 15 to 19, 1931, at Cleveland, Ohio.

Each year we gather together to exchange our opinions and ideas in connection with the new developments that have taken place and also to discuss what problems confront us, with operating our equipment.

A discussion of our experiences, our problems, are of interest to each other and makes for a better understanding of our own plants.

This year an attractive program of papers has been prepared and we are going to be allowed an opportunity to listen to descriptions of some of the recent modern electrical installations. One in particular will be the Twin Motor Drive, located at the Illinois Steel Co. at South Chicago. Another feature will be a Cold Strip Mill Paper.

Open Hearth Furnaces will receive the attention that they deserve and Electrical versus Mechanical Devices for Combustion Control Apparatus for Open Hearth Furnaces will be thoroughly discussed. Another paper of interest will be the practical side of Metallurgical Heating Application.

Our interest in Anti-Friction Bearings is well known and this Committee is presenting some interesting data in connection with Roll Neck and Crane Applications.

Lubrication subjects will occupy one full day at the Convention. Applications to Roll Necks, Roll Tables, Cranes, Machine Tools, Turbines, Motors and Generating Equipment will form this day's work.

One novel development which will be interesting is the Application of Health Lamps to our Industry with particular reference to the health of the employees and their efficiency.

The Inspection Trips will be well worth while.

The Wire and Wire Products Division has a very good program arranged consisting of eight papers concerning the Wire and Wire Products Industry.

The June number of the Iron and Steel Engineer, the official medium of our Association, will contain the papers to be presented, list of exhibitors and their booth numbers, and all the information in connection with the Convention and Exposition.

The Railroads are co-operating with us on the basis of one and one-half fare.

The Exposition, as usual, will be a most interesting exhibit of all the recent developments of apparatus used in the Iron and Steel Industry.

Make your plans to attend the Convention and Iron and Steel Exposition.

Ladies' Program will also be of interest.

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OIL CIRCUIT BREAKER APPLICATION

—in—

THE IRON AND STEEL INDUSTRY

PRESENTED BEFORE

THE

Association of Iron and Steel Electrical Engineers

WILLIAM PENN HOTEL **PITTSBURGH, PA.**

PAPERS PRESENTED

STEEL PLANT SYSTEM ANALYSIS—THE SHORT CIRCUIT STUDY, by M. J. Wohlgemuth, Engineering Division, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

SELECTION OF OIL CIRCUIT BREAKERS, by J. D. Greensward, Electrical Engineer, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

DISCUSSION ON OIL CIRCUIT BREAKER APPLICATION IN THE IRON & STEEL INDUSTRY, by B. M. Jones, General Engineer, Duquesne Light Co., Pittsburgh, Pa.

DISCUSSED BY

F. D. Egan, Electrical Superintendent, Bethlehem Steel Company, Lackawanna, N. Y.

C. H. Black, General Electric Company, Philadelphia, Pa.

S. A. Canariis, Technical Representative, Duquesne Light Co., Pittsburgh, Pa.

A. C. Cummins, Electrical Superintendent, Carnegie Steel Co., Duquesne, Pa.

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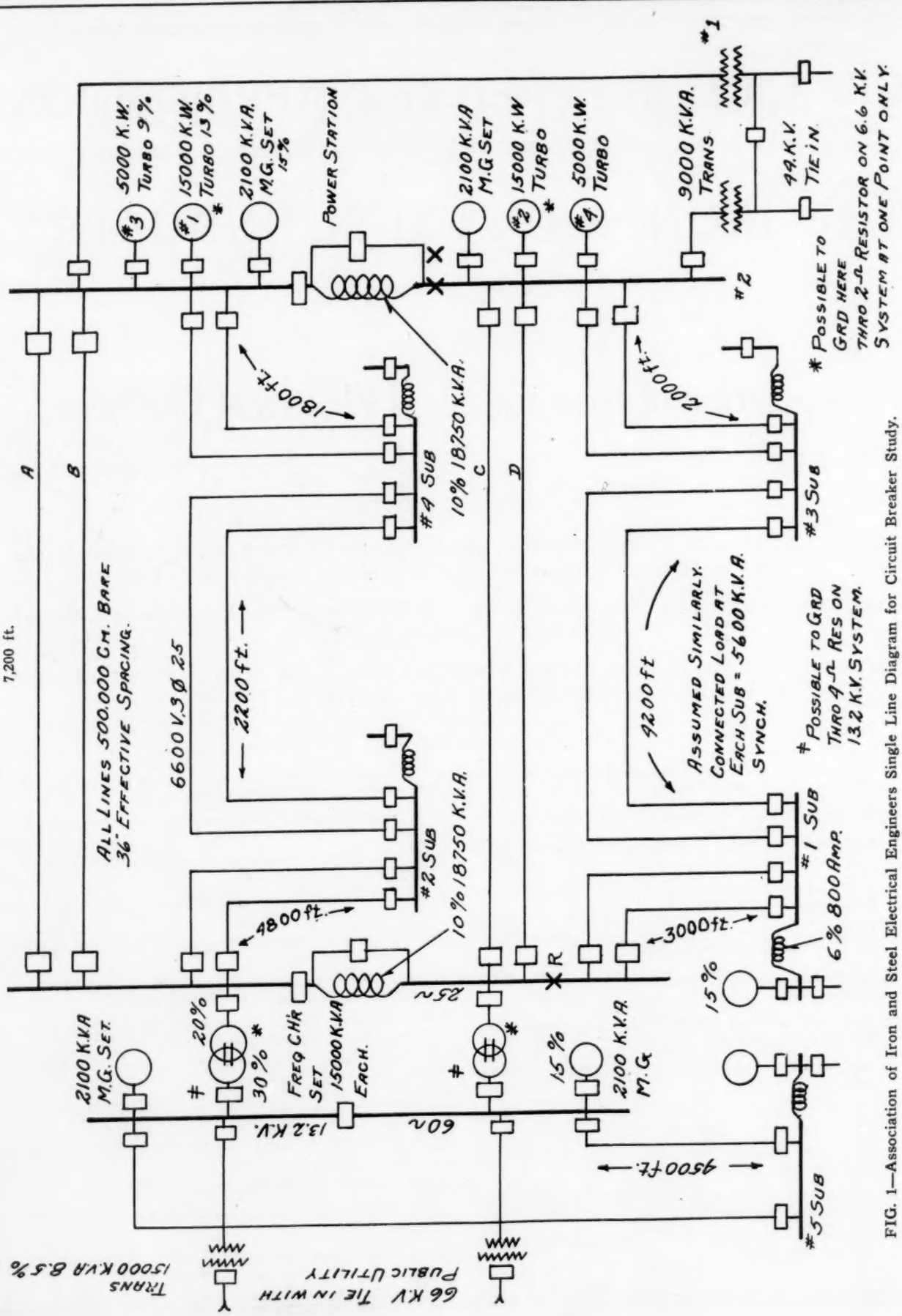

FIG. 1—Association of Iron and Steel Electrical Engineers Single Line Diagram for Circuit Breaker Study.

Steel Plant System Analysis— The Short Circuit Study

By M. J. WOHLGEMUTH*

The subject under discussion is undoubtedly one that is receiving widespread attention of practically all steel mill electrical engineers. With the large amount of electrification of mills now being installed and contemplated, it is a vital factor, that the distribution system be of such a nature that service will be as near perfect as possible.

In order to attain this ideal, it is necessary to consider several items of prime importance, the use of which will determine the success of the system. These are:

(a) The use of a system of lines which will enable service to be maintained at all mill substations, but without introducing a complicated system of feeders.

(b) Installation of adequate switching devices, which will enable any portion of the system, which may be in distress, to be cleared without affecting the remainder of the system.

(c) Installation of adequate relaying devices which should be simple in character, yet effective in isolating trouble through the switching devices, on any portion of the system without affecting the remainder of the system.

(d) A possible installation of reactors at stragetic points which may allow the use of smaller switching devices, but whose primary function is to hold up voltage on the system during periods of short circuit. It should be noted that the indiscriminate use of reactors may do more harm than good, and a careful study of this problem is necessary.

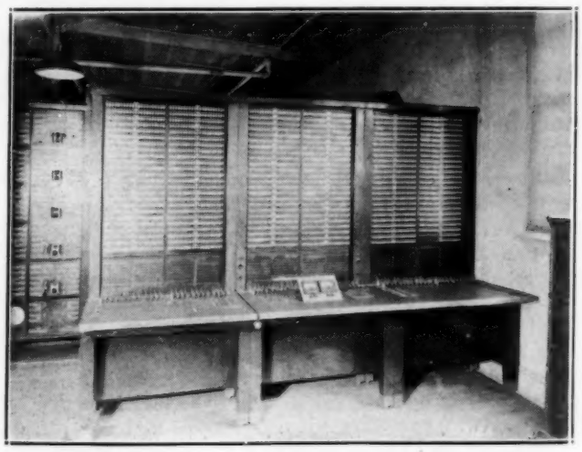

FIG. 2.

In order to illustrate clearly the methods followed in analyzing a system and how the various items of switchgear, relays, etc., are chosen, a typical steel plant system has been selected. This is shown in Fig. 1. It will be noted that a loop system has been provided, which is undoubtedly considered the most flexible that can be employed.

*Engineering Division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

It will be seen that the loop consists of four lines per side, with the loop arranged so that there are at least two lines looping in and out of each substation. The loop form of transmission system allows power to be furnished to any substation even though the loop lines between any two substations are out.

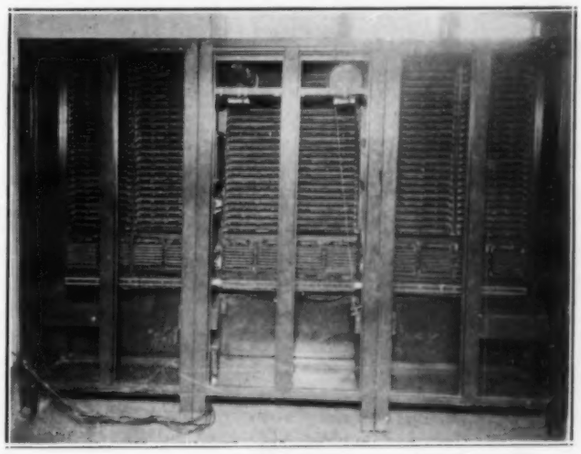

FIG. 3.

The system was set up on a calculating table, such as shown in Figs. 2 and 3. It is not the purpose of this discussion to go into detail on the solution of short circuit currents by means of the calculating table. In general, the system is set up in miniature form by connecting together a number of adjustable resistor units representing proportional reactance values of the actual system connections. A known d.c. voltage is impressed between a positive bus, to which all resistor units representing generator are connected, and some point of fault. A reading of amperes for total current, as well as for branch current, will give values proportional to the instantaneous symmetrical current for that particular fault point.

The setup was made on the table without any reactors in the bus at the power house and frequency changer substation. Readings were taken for short circuit currents at various points of fault, as shown in Fig. 4 and 5, item A and C. It should be noted from the tables that the amount of short circuit current feeding into a fault from all possible sources is easily determined by means of the calculating table.

With the value of short circuit current that can be obtained, the voltage on the bus at either the power house or frequency changer station would collapse at the instant of short circuit conditions. This, of course, is not desirable as it would drop out all rotating equipment on the system and would defeat our purpose in attempting to set up an ideal system. It is at this point that we must consider the use of reactors in order to maintain the voltage.

In looking over the system it becomes apparent

that an ideal location for reactors would be in the busses of the power house and frequency changer substation. The machines in each station are of such a character and of such number that they can be isolated symmetrically by means of a bus reactor. Accordingly, this was done on the calculating table, using a reactor with value of 23% on 18750 kv-a. The values of short circuit currents were taken with this set up and are as shown in Figs. 4 and 5, items B and C. It will be noted that the values are considerably lower than without the reactors and, of course, are gratifying as it means a smaller investment for switchgear devices. The more important feature, however, is the improvement in voltage conditions.

POWER SYSTEM SHORT CIRCUIT STUDY FOR BREAKER APPLICATION FAULT CURRENTS ON 25 CYCLE SYSTEM AS OBTAINED WITH D.C. CALCULATING BOARD

A. At Power House, Location X, No Bus Reactors.

Feeder	1. S.R.M.S. Amps.	¼ Sec. Decrement	¼ Sec. Net
A, B, C & D	5320	———	5320
#4 Sub.	3700	———	3700
#3 Sub.	3300	———	3300
Transf. #1	7360	———	7360
Transf. #2	7360	———	7360
Gen. #1	12000	3500	8500
Gen. #2	12000	3500	8500
Gen. #3	6000	2350	3650
Gen. #4	6000	2350	3650
M.G. #1	1200	200	1000
M.G. #2	1200	200	1000
Total	65440	12100	53340

B. At Power House, Location X, With Bus Reactors.

Feeder	1. S.R.M.S Amps.	¼ Sec. Decrement	¼ Sec. Net
C & D	4800	———	———
Sub. #3	4600	———	———
Bus Reactor	5100	———	———
Transf. #2	7400	———	———
Transf. #1	2000	———	———
Gen. #2	12000	3500	8500
Gen. #1	3250	250	3000
Gen. #4	6000	2350	3650
Gen. #3	1600	450	1150
M.G. #2	1200	200	1000
M.G. #1	300	0	300
Freq. Ch. #2	3500	320	———
Total	51750	7070	44680

Fig. 4

C. Fault at Frequency Changer Station, Location R.

Feeder	No Reactors 1. S.R.M.S. Amps.	With Bus Reactors 1. S.R.M.S. Amps.
A & B, Each	10000	2050
C & D, Each	10000	10000
No. 3 Sub.	8000	1700
No. 4 Sub.	8000	8600
Thro Reactor	———	5100
Thro Reactor Bkr.	22000	———
From Freq. Ch. #1	6600	1350
From Freq. Ch. #2	6600	6600
Total	48600	31200

At Substations, Total R.M.S. Short Circuit Current With Reactors in Power Station Buses

#1 Sub.	#2 Sub	#3 Sub.	#4 Sub.
26,000	28,500	32,000	32,600

On Substation Feeders, With Feeder Reactors.

#1 Sub.	#2 Sub	#3 Sub.	#4 Sub.
10,500	10,500	11,000	11,200

Calculated Fault Currents on 60 Cycle System

Assumed that Voltage is Maintained on 66 Kv. Bus.

1. Fault Assumed on 13.2 Kv., 60 Cycle Freq. Ch. Bus.
   2—Transformer banks, each 15,000 kv-a., 85% X.
   S.C. Amperes—$\frac{2\text{x}15{,}000\text{x}100}{13.2\text{x}1.73\ \ 8.5}$=15,450
   2—Frequency changers each, 15,000 kv-a., 30% X.
   S.C. Amperes—$\frac{2\text{x}15{,}000\text{x}100}{13.2\text{x}1.73\ \ 30}$=4370.
   From #5 Sub., inappreciable.
   Total Fault Current at Bus 19,820.

2. At No. 5 Substation 13.2 kv. bus.
   2—Lines each 4500 feet long, 36 inch effective spacing. .49 ohms each = 2.1% reactance on 15,000 kv-a. base.
   Equivalent Reactance at Freq. Ch. Bus on 15,000 kv-a. base = $\frac{655\text{x}100}{19820}$=3.3
   Combined Reactance to No. 5 Sub. = 3.3+2.1=5.4%
   Total fault current from Freq. Ch. Sta. $\frac{-655\text{x}100}{5.4}$=12,100 Amperes.

Fig. 5

Considering a fault at X, it will be seen from the table in Fig. 4 that the short circuit current through the bus reactor is 5100 amperes. The reactor is rated at 23% 1600 amp. The drop through the reactor is, therefore:

$$\frac{5100}{1600}\text{ x }23\% = 73\%$$

In other words, the voltage on the bus section in trouble will be less than 30% while the voltage on the rest of the system will be well above 70%. With this value of voltage, the synchronous equipment will be held on the line without any difficulty on the part of the system not in trouble. The same argument, of course, will hold for the faults at other points in the system. The use of these reactors is, therefore, necessary.

The value of short circuit currents at the various substations connected to the 6600 volt system are shown in Fig. 5. In case of a fault on a substation bus, the voltage on the bus will drop to practically zero although the power sources will endeavor to hold up the voltage. It was deemed advisable to install bus reactors at these substations, the value chosen being 6% 800 amp. The short circuit currents for duty on the feeder breakers will be as indicated in Fig. 5. With a fault on the feeder section, the voltage drop through the reactor will be approximately 71%. In other words, voltage on the loop section of the bus will be above 70% although the various machines on the feeder section of the bus will drop out. This is desirable, of course, as the part in trouble should be isolated.

Information is now available for choosing the proper oil breakers and associated equipment for the 6600 volt system.

The tie-in with the 60 cycle public utility system presents a problem which is rather new to steel mill engineers. The capacity, due to connected load, in

several of our larger plants, has reached a point where it becomes impossible to generate the necessary energy. The next step, of course, is the tie-in with the power company. This has become apparent with several of the large plants even though the steel plants are interconnected among themselves, as indicated on our system diagram.

The voltage of the 60 cycle service, it will be noted has been chosen at 13200 volts. This 60 cycle service being the first one in the plant, it was felt that a higher voltage than 6600 volts should be used, in view of the possible large loads that might be connected to this source. At the voltage chosen, considerable blocks of power can be used without using extra large lines or switching devices. It is also possible to obtain machines for 13,200 volts without any difficulty and without much increase in cost.

An analysis of this 13,200 volt system gives the following results:

(a) Short circuit on the 13.2 kv. bus, 19,820 amperes.

(b) Short circuit on Sub #5 bus, 12,100 amperes.

The decrement on the main bus will be very small and can be neglected. The decrement at Sub #5 will also be small compared to the total current.

These values are then used to choose the switchgear devices for the 13,200-volt system.

Selection of Oil Circuit Breakers

By J. D. GREENSWARD*

In the selection of an oil circuit breaker for any system, it would be well to first review the basic action of the oil circuit breaker.

The oil circuit breaker may be considered a generator of gas and the ability to predetermine how the breaker will act, depends largely upon the ability of the designer to calculate the volume of the gas generated under a given condition and the time during which it will be generated. Of course, the effect of the gas generated on the oil circuit breaker and its structure determines whether or not the breaker is suitable for its application, in reference to interrupting capacity.

The determination of the interrupting rating of an oil circuit breaker is complicated by the fact that there is no "yardstick" of standard interrupting capacity to which the breaker can be referred and so far it has been impossible to exactly duplicate successive test results.

When an oil circuit breaker is opened under load, an arc is formed between the stationary and the moving contacts, the size of the arc depending on the voltage, the amount of current and the rate of contact separation. During this period, the arc burns away some of the arcing contacts and some of the oil surrounding the contacts, forming a gas bubble, the size of which depends on the amount of current flowing and the time duration of the arc, and the arc length.

The ability of the circuit breaker structure to withstand the pressures set up by this gas and to extinguish the arc without injury to the structure is a measure of its interrupting capacity.

So far there has been no trouble in building circuit breakers to meet the interrupting capacity in the electrical systems we have now. The problem is to build an oil circuit breaker, and the rest of the switching structure needed with it, as economical as possible and still be sure it meets the conditions imposed upon it.

The selection of an oil circuit breaker for application to an electrical circuit or system requires a knowledge of the characteristics of the system which can be pictured before you and calculated and also requires a knowledge of the breaker itself.

*Electrical Engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Manufacturers of breakers publish these characteristics in a so-called rating sheet which includes their rated voltage, rated current, rated frequency, interrupting capacity and momentary current carrying capacity.

A certain part of a system may be classified according to its normal voltage, normal current, normal frequency, and the transient conditions liable to be encountered. The system conditions having been reviewed, the purpose of this discussion is to review the characteristics of the oil circuit breaker and match the two for a proper installation.

1. Voltage:

The rated voltage of a breaker is the maximum R. M. S. voltage between any two wires of any circuit to which the breaker should be connected. The factor of safety of a certain rating is defined in A. I. E. E. rules and is further supplemented by the practice of various manufacturers in how they believe apparatus should be designed.

2. Current:

The rated current of a breaker is the maximum R. M. S. amperes which it will carry continuously with a certain temperature rise. The frequency is also specified with the current because certain parts of some breakers will carry more current at lower frequencies with the same temperature rise. Here again the allowable temperature rise is defined by A. I. E. E. and is adhered to by the manufacturers.

3. Interrupting Capacity:

The interrupting capacity of an oil circuit breaker is the highest current in R. M. S. amperes which it will interrupt at any specified voltage, frequency and duty cycle. Breakers are listed in the rating sheets of the manufacturers on the so-called 2 O.C.O. duty cycle which is two complete open-close-open operations with a two minute interval between the two cycles.

Stating it a little clearer, the interrupting capacity is the highest current at a specified voltage which the breaker can interrupt when closed against a short circuit followed immediately by the re-opening of the breaker without purposely delayed action; allowed to remain open for two minutes; and then closed again against the short circuit, followed im-

mediately by the re-opening of the breaker without purposely delayed action.

The breaker should perform its rated duty under these conditions without emitting flame and at the end of the duty cycle be in substantially the same condition as at the beginning. It shall be also capable of carrying rated voltage and its main current carrying parts shall be substantially in the same condition as at the beginning, but its interrupting capacity may be materially reduced.

The measure of the current interrupted is taken during the first half cycle of arc between contacts during the opening stroke.

4. Momentary Current Carrying Capacity:

The one second or momentary current ratings are the maximum which the breaker will safely carry for any period, however, short. This takes into account the mechanical stresses set up in the breaker as well as the thermal carrying capacity. Either one of the two may determine the momentary rating. The five second rating is the maximum current which the circuit breaker will safely carry for a period of five seconds, which is a measure of the thermal capacity.

All of the above can be determined by the manufacturer by tests except possibly the interrupting capacity of very large breakers. In this case the designer must be guided by experience with the smaller breakers and also the performance of the breakers on the systems on which they are installed.

There are a number of cases where the voltage rating of a breaker as given in the above definition will not work out satisfactory. Where the bushings of a breaker are exposed, the particular dust and dirt conditions encountered in special processes of manufacture such as steel mills, sulphur plants, and outdoor breakers close to spray ponds cause bushing failures which in many cases are just as annoying and serious as if the breaker tank itself gave way. Bushing failures also cause severe duty on the oil breakers that must clear the short-circuit and in this way may cause shut down on more than one part of the system.

There are some cases on record where a small generating plant is tied in with a large power company, and if this power system has sluggish governor control such as may be encountered in hydro-generators, a fault in the outside system causing the generators to drop load may pick up the load of the small generating plant, raise the system voltage, and when the two systems are separated the voltage that the separating breaker is called upon to interrupt is considerable higher than designed for and causing sustained arcing and complete failure of the breaker. This danger, however, is quite remote with the power companies keeping up-to-date in their equipment as most of them do and need to be kept in mind only in very remote cases.

The current rating of a breaker must be selected by the highest continuous current passing through it. In other words, it is a maximum rated machine and if a motor with a two hour overload period is connected to it the breaker selected must have a rating equal to the two hour period of the machine. In this connection watch the momentary rating required as it sometimes varies with the current rating.

In the application of breakers, for rolling mill schedules, there are times when the continuous current rating of the breaker does not need to be as large as the peak currents of the motor. These peak currents last for such a short time that when a definite maximum schedule is established, according to the size of the motor, the heating liable to be encountered in the oil circuit breaker, can be figured the same as is done with the motor and a circuit breaker selected accordingly. It is merely necessary that the resultant cycle of currents over a period of time does not generate enough heat in the breaker to exceed the temperature rise limit as set by the Standards. In this connection, the momentary or five second ratings of the breaker do not come in the calculation as they are usually never approached under the peak load current conditions.

There are times when a breaker is used for more or less contactor duty for starting and stopping the motor quite often and in these cases, as when the motor is opened on overload, the arcing tips receive more than the normal abuse. When this is the case, the maintenance of the breaker must be watched carefully and a breaker selected suitable for this heavier duty.

Breaker Selection for This System.

Starting with the power plant as shown in the drawing there are four different rupturing capacity figures by which the breaker could be selected. It is possible to take into consideration the reactor in the bus and also the decrement at the end of a quarter second.

We believe that the proper application would be to take care of the worst possible condition when selecting the breaker. In other words, taking care of the instantaneous current liable to be encountered without the reactor in the bus, which would allow for a margin of safety over the usual conditions.

Another thing usually watched in the locating of switching equipment, is to locate the generators and the outgoing feeders in such a position that under the usual conditions there is very little exchange of power over the complete length of bus. This has already been taken care of as the single line diagram shows a symmetrical layout both in regard to the generators and feeders.

The ampere rating of the breakers selected would be according to the rating of the various generators and feeder load unless it was found desirable to keep a duplication of breakers from the maintenance point of view. In this connection the momentary current rating of the breaker sometimes changes with the ampere rating and should be watched here. Duplication of breakers, of course, keeps down the number of spare parts to be carried by the plant, which in a system of this size is quite an item. On the other hand, in large systems there is usually a considerable saving of initial expense by picking the breaker for its own service, without regard to duplication. In matters of this kind, it is up to the electrical engineer of the system to decide the probable growth in load on the various feeders and in this manner select as many duplicate breakers as is possible in regard to current rating wherever the interrupting capacity and voltage is the same.

For the power plant, we would recommend an oil circuit breaker of 7500 volts, if enclosed, and one-half million K.V.A., interrupting capacity, which is 52,500 amperes at 6600 volts. The reason for this is because it is the closest standard manufacturers rating and is near the rupturing capacity figured

without the reactors and allowing for one-quarter second decrement. No smaller than 1200 ampere breaker should be used because of momentary rating. A 750,000 K.V.A., breaker is at present the next highest standard and there is some question as to whether or not it should be used. If the system set up were to be changed at any time, requiring a little higher rupturing capacity, it certainly should be used. This same breaker can then be used in the frequency changer station on the 25 cycle system and in substation No. 2, 3, and 4. It would be possible to use a little lower interrupting capacity in these substations. The nearest lower Manufacturer's Standard would be 350,000 K.V.A., or 36,000 amperes at 6600 volts.

Substation No. 1 would also require the 350,000 K.V.A., breaker being the closest standard, but if duplication is desirable, the one-half million K.V.A., breaker would again be used. The 250,000 K.V.A., breaker is right on the line and should not be used.

The circuit breakers referred to above for the substations, were all for the loop (supply) side of the interconnections between substations, power plant and frequency changer bus.

The circuit breakers for the load connections for these substations are all connected through the reactor and for this reason, a circuit breaker of 125,000 K.V.A., which is the closest Manufacturer's Standard would be used in all these substations. The standard 800 ampere or 1200 ampere circuit breaker would do in all cases, as the momentary current is not high enough to require larger breakers than this.

The 13,200 volt station would require breakers 15,000 volt, 500,000 K.V.A., or 22,600 amperes at 13,200 volts, rupturing capacity the same as at the generating station. The short circuit current is low enough so that the breakers can be selected for their current rating as the momentary rating is not too high for ordinary breakers.

The No. 5 substation requires a rupturing capacity of at least 350,000 K.V.A., 15,000 volts, as the required condition is just a trifle above the 250,000 K.V.A., breaker.

Conclusion.

In all cases where oil circuit breakers are selected for a particular duty, it is well to remember that a margin of safety is desirable in the selection of the breaker. A year after the installation, the breaker may not have as large an interrupting capacity as when it was first installed due to the various conditions encountered, such as low dielectric oil, arcing tips in poor condition, and operating mechanism in bad shape, giving a slow speed of break. The designer can predict what the breaker can do if in proper condition, but if not in proper condition, the characteristics of the breaker itself changes materially.

The main points in selecting a circuit breaker is to have a rugged mechanical construction; have the circuit breaker and other switching equipment enclosed from outside influences; and the safety features.

The fact that the safety features were mentioned last should not in any way detract from your attention the importance of this item. The program of safety that most industries are going through at the present time, especially the Steel Industry, requires that all switching equipment be installed that has absolutely no hazard to the operators or maintenance crew. The truck type equipment meets this admirably and the last work in safety is, of course, the armorclad equipment. Armorclad equipment is designed by the various manufacturers, makes it impossible for the operator or maintenance crew to go through the wrong sequence of operation when taking a unit out of service and the grounded metal casing on the exterior of all conductors makes it impossible for them to come in contact with alive conductors.

The armorclar enclosure also gives the greatest possible protection against external influences such as dust, etc., and in cases of trouble to a particular unit, this construction makes it absolutely impossible for the trouble to spread to adjacent switching equipment.

ASSOCIATION OF IRON & STEEL ELECTRICAL ENGINEERS CONVENTION AND IRON AND STEEL EXPOSITION

JUNE 15-16-17-18-19, 1931

ELECTRICAL, MECHANICAL, LUBRICATION, COMBUSTION, SAFETY ENGINEERING DIVISIONS, AND WIRE & WIRE PRODUCTS

EXPOSITION—CLEVELAND AUDITORIUM

OFFICIAL CONVENTION HEADQUARTERS — STATLER HOTEL

ALL TECHNICAL SESSIONS—CLEVELAND AUDITORIUM

ALL SOCIAL FUNCTIONS—CLEVELAND AUDITORIUM

ALL ACTIVITIES UNDER ONE ROOF

FIG. 1—Testing 24 K.V. Oil Circuit Breaker for Destruction.

Discussion on Oil Circuit Breaker Application in Iron and Steel Plants

By B. M. JONES*

I am very glad of this opportunity to make a few remarks on this subject which I feel is of great importance to the steel plants and electric utility companies and manufacturers of electrical equipment, and certainly appreciate the permission of Messrs. Kelly and Dudley for me to break in on your scheduled program for a few minutes.

The Chairman, Mr. Dudley, stated that the subject of today's paper and discussions might appear dry and uninteresting to some and quite interesting to some others. I have a slide to show and a few remarks to make that I believe will convince all present that the use of the equipment discussed today is far, very far, from uninteresting and dry. We will come to that slide a little later.

*General Engineer, Duquesne Light Co., Pittsburgh, Pa.

We electric utility engineers believe it essential to make the short circuit calculations thoroughly and completely, both for the present system and future growth as outlined by Mr. Wohlgemuth, and have at certain times installed reactors at stragetic locations to reduce the short circuit duty, both for saving in breaker cost, better performance of the breaker and less system disturbance. Our Company, the Duquesne Light Company, bought a short circuit calculating board of the D.C. Adjustable Resistor Type, several years ago, and use it very very frequently in our short circuit studies, particularly when any new additions to the system or any re-arrangements are considered.

We have been able to do more short circuit studies, and to apply our breakers more intelligently

since the purchase and use of this table than we had in the past, and at a much reduced engineering expense on this portion of the job, and we feel at a more solid basis for applying our breakers.

We also believe that the selection and application of the circuit breakers for the duties that are imposed on them, both at the present and in the future, is a very important matter, particularly in a system that is likely to grow or expand, or is likely to be re-arranged to any material extent. We pay very particular attention to the selection of circuit breakers and their applications, making a very thorough study of each individual application, and we believe that following this practice for the last six or seven years has materially reduced our circuit breaker troubles, and operating and maintenance costs on them.

Hand in hand with the short circuit study and the careful and intelligent selection and application of circuit breakers, we feel very strongly that the testing of circuit breakers for their interrupting capacity before being applied is just as important as the facts brought out in the first two papers presented this afternoon.

We all know that the oil circuit breaker, as an interrupting device, is undesirable due to the fact that the oil is inflammable and therefore a fire hazard, and that due to containing oils, the breaker requires considerable maintenance and attention and the inherent expense. If we could find some device for interrupting these currents at the various voltages without the use of oil, we would certainly adopt it. Several manufacturers of electrical equipment have been searching diligently for quite a few years, and at a considerable expense, for current interrupting devices without the use of oils or liquids, and we are hopeful that the day is not far distant when their efforts will be successfully and economically rewarded.

Our Company about five or six years ago, in fact in 1924, began testing oil circuit breakers for their interrupting capacity for use on our system, and since that time have made a large number of interrupting capacity tests covering a wide range of voltages and currents.

The ranges of voltage and currents included 2300 volts to 66000 volts and 1,000 amperes to 12,000 or 13,000 amperes, and involved Kv-a. of 80,000 to 700,000.

About 1923 or 1924 our tests brought out the fact that it was very necessary to thoroughly test circuit breakers for their interrupting capacity before this interrupting capacity could be definitely known, and it was a great benefit to the manufacturers as well as the users, for an operating company with a large system capacity to perform such tests on breakers to determine just what they would interrupt.

Obviously, the manufacturers cannot install capacity equal to large operating systems and therefore are handicapped in the design, manufacture and tests of their breakers. Certain defects were shown up in the tests made by our Company and by other operating companies on certain breakers and the manufacturers welcomed these opportunities to find out just what their breakers would do and just where their weak spots were. They immediately corrected these faults, with the result that a better product was available, much to the satisfaction of the manufacturer and user. Previous to about 1921 or 1923 there was very little test data available on high voltage circuit breakers, and the designers were therefore forced to project their design curves and data from smaller breakers on which they had a limited amount of test data in order to determine what, to the best of their knowledge and judgment, was the interrupting performance of the higher voltage larger breakers. This method of applying a rating to a breaker was the only one available at that time and it is generally admitted now that in certain cases the tests form a more exact method of rating a breaker.

Our Company believes strongly in testing circuit breakers for interrupting capacity, particularly a new design or a wide departure from previous designs, or on a breaker with which we are not very familiar. We of course, try to keep posted on what other operating companies are doing in the way of circuit breaker testing and do not like to duplicate tests made by other people.

In 1926 our Company undertook and completed a very comprehensive interrupting capacity test program on 24 Kv. breakers at our Wilmerding circuit breaker testing station.

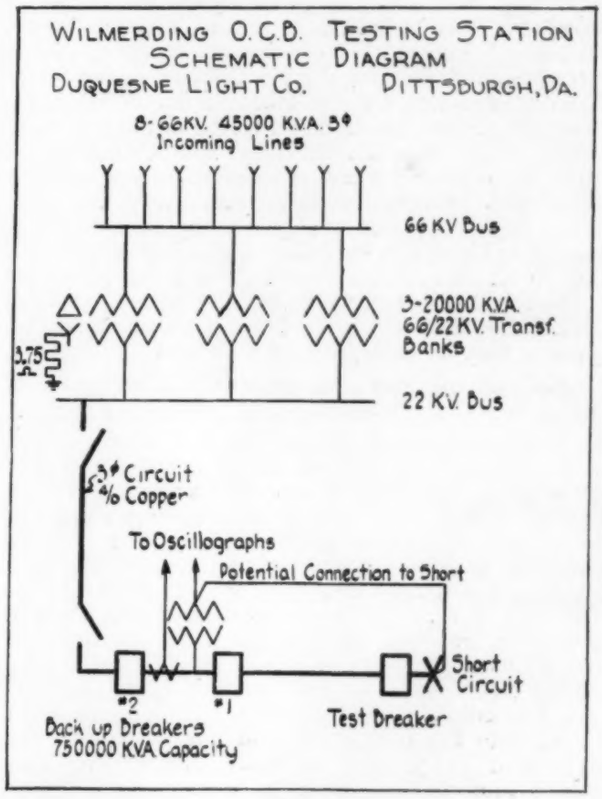

FIG. 2.

Duties from 180,000 Kv-a. to 530,000 Kv-a. were imposed on breakers of several manufacturers during these tests and involved currents from about 4,000 to 12,000 amperes at 24,000 volts.

From the schematic diagram of Wilmerding Oil Circuit Breaker Testing Station of our Company, you can see that there are eight 66,000 volt, 45,000 Kva. transmission lines bringing energy into this station, which lines are tied on a common bus. From

this bus three 20,000 Kv-a. 8% reactance transformer banks step-down this 3 phase, 66,000 volt energy to 3 phase, 24,000 volts, and from the 24,000 volt bus there is a 4/0, 3 phase copper circuit run a few hundred feet to the test circuit.

On this test circuit there are two back-up breakers of 750,000 Kv-a. interrupting capacity, which is greater than the breakers to be tested. Along this test circuit there are test positions for five circuit breakers, the plan being to set up many breakers to be tested and after one has been tested to cut it dead and quickly proceed with tests on the others, thus saving considerable time as the making of these tests is quite expensive. The breaker to be tested was thoroughly inspected by the manufacturers before test and by our Company to see that the operating adjustment and other features were in accordance with their requirements. Oscillographic measuring devices were available for recording the performance of the breaker and remote electric control was also available to insure safety to the test personnel while closing the breaker.

Some of these breakers did not meet their ratings and literally "took fire and wings" and from photograph shown in Fig. 1 it is apparent that the explosion or failure of a large oil circuit breaker to interrupt a short circuit, is a serious matter, for this photograph shows this oil fire to be some two or three hundred feet high with a flame at least two-thirds of the way up and smoke the remainder, and some sixty or one hundred feet across at the bottom. A large crowd of witnesses from our Company and from the manufacturers' were seated on the hillside about two or three hundred feet away, and were badly frightened and could feel the heat scorching their face from this explosion and others like it, and they went away from there! The green grass was scorched and burned to a very dry brown grass for several hundred feet around this breaker and it was quite a task to extinguish the oil fire.

Such an oil fire and explosion in an operating station would be disastrous with probable fatalities.

There were many interesting and exciting events accompanying the 1926 oil circuit breaker tests, such as, at one time we had installed an indoor breaker in a small house or shed and had a sheet metal door to enter the breaker compartment. The incoming bare 4/0, 24,000 volt leads came into the side of the building about four feet from the ground and opposite this door. By some mistake (unexplainable) this door was not latched closed at one time, and the wind caught hold of it and slowly blew it open. About five or ten of us happened to be watching and immediately realized that this door would be blown into the live 24,000 volt line and thus create a ground or possibly a short circuit. We were frozen into position with fascination watching this door slowly drift open, and literally could not move until the door struck the line with the resultant large flash of flame and arc. This breaker house was a wooden shack, coated with sheet iron and the wood inside the sheet iron caught fire as well as the oil in the breaker, and the result was a long drawn-out fire that was very difficult to extinguish. Needless to say, we did not test **this** breaker this day.

Another interesting and exciting feature was the drawing together of the bare 24,000 volt leads which were spaced horizontally 24" apart on a pole line, this drawing together being accomplished after the short circuit had cleared for while the short circuit existed the conductors would spread apart, and upon the breaker opening the conductors swung together in the middle of a span between the back-up breaker and the station bus about 150' away. This arc then held on between the three phases on the flat construction and the wind slowly blew it back towards the station. This was a fascinating sight and for a few seconds everybody was again frozen into position and could not take any steps to eliminate it. In the meantime the arc was slowly blown further down the line stripping insulators on each pole and stripping insulators on a set of disconnects in the test circuit. The station was shut down within a 10 or 20 seconds and the arc immediately extinguished itself. Immediately after this we rebuilt this test line and spaced the conductors **10 feet apart on every other pole** to insure the breaking of an arc before it could travel more than one span.

We have made tests on the recent Deion attachment for 66,000 volt breakers for the Westinghouse Company at the same station, modifying the test arrangement to accommodate the high voltage circuits, and much to our satisfaction and the Westinghouse Company's the performance was very excellent. These tests included some 50 test shots both single phase and 3 phase, and one phase to ground involving currents from 1200 to 7000 amperes and the time of extinguishing the arc and the total time of interrupting the short circuits was materially reduced over that of the present day breakers in this class, and with practically no distress upon the breaker—in fact, no distress that we could determine. We felt so well pleased with the Deion Grid on the G-2, 66 Kv. breakers that we have bought some of these attachments for installation in our present G-2 breakers, to replace the present attachments. Total elapsed time for performing these 50 shots was 2 hours and 18 minutes, which we believe is a record and shows that to accomplish such a result there must be a well organized program. Incidentally our Company learned this lesson in 1924 when a few shots a day was big doings (?)—since that time we have been able to lay out a program and carry it through in a very orderly manner. We were very well pleased with the Westinghouse Deion grid attachments added to the G-2 breakers tested in October, and believe that this will be a forward step in the breaker art.

We have made tests on 4 Kv. breakers, 11,000 volt breakers, 24,000 volt breakers, 66,000 volt breakers, and fuses both 4 Kv. and 22 Kv. all with one object in view, of determining the actual interrupting ability of such devices before applying them to our system, as we feel that the protective device is one of the most important pieces of electrical equipment, and one about which it is essential to know the performance under the worst conditions, hence the exhaustive interrupting capacity tests that we make.

The manufacturers are spending vast sums of money to provide testing facilities for oil circuit breakers and are installing larger and larger equipments in their laboratories.

At the present time due to the improvements in oil circuit breakers as a result of our tests and tests by other operating companies and by the manufacturers, we have considerably more confidence in the ratings now applied to the breakers.

Discussion

Oil Circuit Breaker Application in the Iron and Steel Plants

Discussed by

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F. D. Egan: The following information will be necessary before a complete analysis may be made:

Rated voltage of the system.

Percent reactance of synchronous motors at substations frequency changers and transformers.

Percent reactance and rated KVA. of bus reactors.

Kind and size of wire, and specification of insulation if underground cable.

Spacing of wires on cross arms.

Length of lines not given on sketch.

If switches paralleling reactors in station busses are normally open or closed.

If there is any factor to limit the short circuit KVA. capable of being fed by the two 15,000 KVA. bank of transformers other than the reactance of the transformers themselves.

Maximum KW. loads on each line.

There are two banks of transformers connected to power station bus. Are they 9000 KVA. capacity combined or 9000 KVA. capacity each? Does these transformers feed into or out of the system? What is the purpose of the tie oil switch between these two banks?

Assuming two banks of transformers of 9000 KVA. each feeding out of system and all motors and transformers are pulling full load. There is 44,200 KVA. load on 25 cycle system and 9700 KVA. load 60 cycle, total of 53,900 KVA. The generating capacity is 40,000 KVA. and the transformer capacity is 30,000 KVA., making a total available supply of 70,000 KVA. Evidently, the transformers are operated at a reduced load or some of the turbo generators are kept idle as spare units. It will be necessary to know the operating set up of the system to determine the normal and maximum values of short circuit current.

There are four parallel lines connecting the power station with the transformer station with no load taken from either line. What is the purpose of these lines when they are in use? With station busses closed, there is a complete loop system without them and the short circuit currents will be materially increased with these lines in service.

In order to determine the short circuit currents in the system, it is necessary to determine the reactance of the circuit, namely, the % machine reactance and the % line reactance.

The % reactance of synchronous equipment and transformers depends upon the design of the equipment and is expressed as a % of the rated KVA. of the machine. The reactance of the lines is expressed as $X = 2 \pi F L$, where F is the frequency of the system, X the reactance of the line and L the in-

ductance of the line. The frequency being constant, the inductance is directly proportional to the reactance. The inductance varies directly as the distance between the wires and inversely as the radius of the wire and directly as the length of the line. By referring to tables in a relay handbook, the ohms/min. can be obtained from tables for different spacings of the lines and different sizes of wires.

These resistances being expressed as a percent of the rated KVA. of machines and as ohms/min. it is impossible to combine them. It becomes necessary to refer these reactances to some common KVA. base for solving the network.

When the reactances of machines and lines are referred to some common base and their values inserted in a one line diagram of the system, it can be seen that the loops connecting the two power stations are four sided impedance squares for which we have been unable to get a solution. This has been referred to Mr. Rogers of the Westinghouse Engineering Department but as yet have received no solution for any loop more complicated than a delta star or three sided impedance triangle. If you have any vigorous solution to this network, a copy of the calculations will be appreciated as it will help us in future solutions to our own network.

When the reactance of a network is calculated to a particular point, where the short is assumed to exist, the reactance is referred back to the KVA. of the system capable of feeding to the short. From this reactance, the short circuit KVA. can be calculated

$$\text{S.C. KVA.} = \frac{\text{KVA. of Syn. Equipment}}{\text{Reactance calculated}}$$

$$\text{INST. SVM. ISC} = \frac{\text{S.C. KVA.}}{\text{Voltage to Neutral}}$$

The ISC after any definite time can be obtained from tables on Page 28 of Westinghouse publication, S.P. 1666-A.

C. H. Black: Mr. Greensward stated, and the subsequent discussion would seem to indicate, that a definite advantage is gained by applying oil circuit breakers to circuits far below, in actual duty, the breaker ratings assigned to indicate the circuit interrupting ability of those breakers. This practice was recommended even when breakers rated equal to or slightly above the actual requirement were available. One of the reasons advanced for such pessimistic breaker selection was: The actual interrupting ability of an oil circuit breaker might decrease with continued service by reason of oil and contact deterioration and possible impairment of the operating mechanism—all resulting from the possibility of operating for an extended period without inspection.

The interrupting ratings offered today by reputable manufacturers of oil circuit breakers should be verified by extended series of circuit interrupting tests, conducted at the factory, where—in the case of several of the larger manufacturers, testing facilities have been available for a considerable period. Field tests—those described by Mr. Jones, for example—were of inestimable value prior to the existence of factory short-circuit testing equipment, and field tests are still of much importance where voltage and interrupting capacity ratings exceed available factory testing facilities. But the factory facilities today are exceeded, in actual service, only in the case of very high voltage, high interrupting capacity systems, none of which are involved in this discussion.

When such testing facilities are available and are effectively used, a manufacturer has no need for estimating the circuit interrupting ability of an oil circuit breaker, nor does he need to rely upon future performance of that breaker in actual service to substantiate the estimate.

Hence there is a "yardstick" for measuring interrupting ability and it has been rigorously applied in the design of the modern, non-oil throwing oil circuit breakers, with which I am most familiar. For example, we have made more than one thousand circuit interrupting tests upon one specific line of breakers, the line which, incidentally, might be applied at the majority of locations in the system which was just reviewed. With this yardstick available, it remains only for the manufacturer to recognize the necessity for a liberal margin of safety in his ratings,—not in the subsequent application of those ratings. And conservative manufacturers realize that necessity, apply liberal margins of safety, and so obtain an absolutely safe rating,—a "stand-by rating," as one speaker has aptly termed it,—a rating which insures efficient performance with a minimum of maintenance.

But it is futile to expect that—if that minimum of maintenance is not provided—the mere provision of a higher-rated interrupting device will be the panacea for the difficulties which might result. If a mechanism is of such design that continued operation can impair its performance to the point of failure to trip or—having tripped—to open fully, if the oil deteriorates to such an extent that the arc will "hang" past the end of the movable contact travel, or if the contacts burn so that they will not carry normal load without over-heating, of what use is the higher interrupting capacity rating?

Briefly, then, it would seem more in order to so design the breaker that it will meet its rating under all conditions and with a minimum of maintenance, rather than to apply the breaker pessimistically and uneconomically if we are not sure that the margin of safety inheres in the breaker design. We must have the margin of safety and—having it—further derating in the course of application is unjustified from either the viewpoint of economy or the consideration of safe, reliable performance. We may concede, in certain special cases, some such derating of normal current and voltage ratings, where overcurrents or overvoltages may exist for appreciable periods, or where atmospheric conditions warrant over-insulation. But if the actual short-circuit duty is known or is calculable and if a modern, factory-tested, non-oil-throwing oil circuit breaker is available, then there is, I believe, no justification for selecting an unnecessarily high rating.

And now, if I may be permitted a few brief comments upon another topic, I should like to emphasize Mr. Wohlgemuth's explanation that the current values which were given in his presentation of the short-circuit study were based on a symmetrical current wave. The actual currents encountered during short-circuit will, of course, be displaced by an amount dependent upon the exact point in the voltage wave at which initial short-circuit occurs. For full displacement, the r.m.s. value of the initial peak

of short-circuit current will approximate 170% of the r.m.s. value of the same wave, if it were not displaced. This displacement, often referred to as the direct-current component, decays rapidly and usually vanishes entirely within a few cycles, and is therefore not highly important in the discussion of interrupting capacity where relay timing equals or exceeds one-quarter second. It is, however, of vital import in its mechanical effect (arising from the electro magnetic effect of the abnormally high initial peak of current) upon the conducting members and their supports. The mechanical forces engendered by currents exceeding 15,000 or 20,000 amperes flowing through typical oil circuit breaker structures are by no means inconsiderable, and the forces due to currents of 40,000 amperes and above are measured in hundreds of pounds. It thus becomes obvious that the one-second rating of an oil circuit breaker must be your guarantee from the manufacturer that the breaker will not only withstand the thermal effects of that current flowing for one second (which is not a difficult end to obtain, and—furthermore—which represents a circuit condition almost impossible of attainment) but that the contacts and their supporting members will also withstand the high mechanical forces involved during the initial peak but decreasing rapidly thereafter. Prevention of mechanical distortion is the principal factor; the requisite thermal capacity can usually be very readily obtained, once the contact studs and other conducting members are made rugged enough, mechanically. And let us bear in mind that the r.m.s. current, initial peak, may be—and frequently is—170% of the maximum initial values indicated by Mr. Wohlgemuth.

Current transformers must, of course, withstand the same current conditions as the oil circuit breakers when a short-circuit occurs. Their basic characteristics, however, are somewhat different and they are therefore assigned two ratings—one a momentary or mechanical limitation and the other a one-second rating, which is purely a thermal limitation. In any application it is highly desirable, and in the case of a factory built equipment it should be considered essential that all series-connected devices (such as the breaker, the transformers, the bus bars and connections) be consistently rated. More specifically, the current transformers must withstand any current condition which can exist in the circuit, within the limitations imposed by the rating of the oil circuit breaker which, of course, is assumed to have been properly applied.

May I also note just a word of approval, from the manufacturers standpoint, of the expressed tendency to step up operating voltages wherever possible. Certainly the switchgear becomes much more economical and easier to maintain and operate if abnormally high load currents can be avoided. This is especially true if currents can be limited to 2000 amperes or less.

Distortion of oil circuit breakers has been mentioned. The remedy, of course, is to obtain a non-oil-throwing breaker having the shape of structure which offers the greatest possible resistance to distortion and having, of course, adequate material to withstand pressures considerably above those which are expected in interrupting full rated short-circuit currents. A breaker which will distort will allow excessive oil throw, even though the breaker structure may not be permanently affected or destroyed. An excessive oil throw, in addition to the obvious fire hazard, entails excessive maintenance and the elimination of the possibility of repeated operations.

And, speaking of repeated operations, may I say that—while we have no intention of deviating from the standard 2-OCO duty cycle—modern non-oil-throwing breakers are continually being subjected, both in factory tests and elsewhere, to test series far exceeding that duty cycles, with entirely satisfactory results. The standard duty cycle will probably be retained as long as oil-throwing breakers must be rated on the same basis, because with such breakers there is no assurance that additional operations would not lower the oil level to a dangerous point. But for the non-oil-throwing breakers, the margin of safety—which I have previously referred to—allows a large number of repeated operations at full duty without inspection and without appreciable oil deterioration. In our factory testing programs, for example, we cannot afford to remove the tanks and inspect the contacts and oil after each duty cycle but continue our tests without interruption for series of ten, twenty, or in some cases fifty tests. Of course, in actual service such a large number of full capacity interruptions without inspection could not be recommended because of the widely varying time elements involved, but I am outlining these facts merely to provide you with some assurance that operation in one duty cycle is by no means the absolute limit of modern, non-oil throwing, factory-tested, oil circuit breakers. Sufficient time must be allowed, however, for the pressure to be relieved through the separating chamber provided. Otherwise the standard derating factors for very rapid reclosures must be applied.

S. A. Canariis: The papers presented this afternoon impressed me as applying only to comparatively large systems such as the U. S. Steel Corporation or J. & L. Steel Company. I think that mention might also have been made of breaker applications for smaller systems, with demands of a few thousand KVA., and served from a public utility system. One of the difficulties encountered in such systems is the ground protection, and it is seldom considered even in plants with otherwise up-to-date protection. The omission of this ground protection often results in small ground faults in rotating machines or in cables developing into maximum short circuits which may not only cause interruption of the entire service but may also seriously damage expensive equipment.

In the layout discussed we had a grounded 6600 V. system, and the ground protection was, of course, a fairly simple matter. However, when taking service from a power company, and through a step-down transformer bank, say from 22,000 to 2200 V., connected delta-delta, the protection against ground faults becomes more complicated. Evidently the most logical and most satisfactory method is to ground the secondary (2200 V.) system through a grounding transformer bank with neutral resistor, thus practically changing to a grounded system which may be protected as mentioned.

As regards maintenance of oil circuit breakers, mention was made of the decrease in flashover value due to dirt accumulation. This is true only to a certain extent. Judging from the experience of Mr. Cummins with the outdoor 44 KV. substation in Duquesne, even a very excessive accumulation of

dirt does not seem to have given them any trouble. I am inclined to believe that most failures occur through the use of equipment of insufficient flashover value. You will often see 4500 V. breakers on 2300 V. service, where not less than 7500 V. breakers should have been installed in order to obtain a fair factor of safety. Even a 15,000 V. breaker is not of too high a rating to use on a 2300 V. system especially in locations exposed to dirt. I rather think that most failures (flashovers) are due to switching and lightning surges, and that not enough attention is paid to providing adequate lightning arresters to limit such surges.

There seems to be a lack of knowledge between the operators as to the proper maintenance of oil circuit breakers. You see breakers which are supposed to be adequate for the service, subjected to repeated automatic operations without receiving any kind of inspection, testing or checking of oil and contact condition, with the inevitable result that they finally fail. It seems to me that the A. I. & S. E. E. might do some good work in working out a code for proper maintenance of oil filled equipment.

As regards truck-type breakers and metal-clad switch gear, such equipment gives an installation that is almost ideal. However, if your particular plant set-up is not applicable to the use of such equipment, or if the first cost seems too excessive, it is well worth while to consider interlocking your present type breakers and disconnecting switches, and enclosing the entire structure with steel or other fireproof and explosionproof material, to obtain a fair degree of safely for the operators. We have found such an arrangement more economical, as the design of truck-type breakers and metal-clad equipment is being changed too frequently.

A. C. Cummins: I do not believe there is very much that can be added to the discussion of the afternoon, except as far as I am concerned, possibly to give a word of advice based on some practical experiences in making short circuit tests on one of these calculating boards.

About three years ago the Carnegie system was combined into a small super-power system, and it became necessary to pre-determine what size the circuit would grow to and what changes would be necessary to take care of short circuits. About four of us worked six weeks on one of these calculating boards and figured the short circuits out on the basis of the system as it existed then. Some recent developments have come along which changed the claims that were assumed at that time, and I think the point everybody should keep in mind is that it is essential to very carefully and clearly tabulate any data that you secure when operating one of these test boards, so that it can be applied accurately and easily to alterations of the original assumptions. The man who was in charge of this work for us was very systematic and most of that data was in a form that it would be available for alterations, and makes it unnecessary to go through that whole work again. It is a very simple matter to see that if many items would have been omitted before, we would have to do all that work over again. And I would like to give that word of warning to anybody doing that work to put your data down in a form that you can recognize two or three years later and convert it if there are changes made in your original assumptions.

I believe the time is going to come when nearly every steel plant will have some short circuit board of their own. The boards that are in the plants of various manufacturers and public utilities are pretty complicated. It would not be a difficult problem, as one of the West Penn engineers told the Association about a year ago, if permanent resistances represent your permanent equipment, and having it all calculated on that basis, it would be applicable to any system; but the average steel plant has to continually make changes and additions as your improvements went through, and I believe they figured they could put one up for $400 or $500. We never did, but I hope we will, and if you have such a board the matter of determining requirements for the conditions when short circuits occur becomes a simple matter. You can go out to your laboratory and determine what your equipment in the way of oil circuit breaker application should be.

Another thing apparent from the discussion this afternoon is the fact that there have been some material developments in the past three or four years in the schemes of relaying on these short impedance lines around steel mills. Believe some of these combined current, reverse power, ground relays are of recent development; at any rate their application is recent to steel mill lines, and offers opportunities which make feeders more and more attractive as time goes along.

R. M. Hussey: These three papers this afternoon were very interesting and dealt with a very pertinent subject. It is a subject we have had something to do with at Aliquippa Works. My part in that work was not so much in investigation or making the figures, as it was in abiding by decisions that were the result of those investigations and tests, and I can speak on this subject for a minute or more in a practical sort of a way.

We undertook revamping the entire 6600 volt system about 1923 and carried the work along in about those steps we could handle easily and take care of most expeditiously until at the present time the program is nearly 100 per cent complete. We spent quite a lot of money for new equipment and naturally we had to propound good sound business reasons for undertaking such work. It is only natural that after you do a lot of work of that kind and spend a lot of money that you should look your work over. It is done to see what good has come of it; to sort of check up and see if you were justified in doing the work. In that paper Mr. Dudley referred to, beginning with the year 1924, there was a description of some of our power disturbances on that system, and we chose to describe the disturbances as complete failures and partial failures. Complete failures were those in which the 6600 volt system was deenergized by reason of some trouble; partial, where the disturbances were isolated or localized. In 1924, when our records were complete, we had eleven of those complete failures of power on our system. Those troubles decreased as more revamping work was done until in 1928, there were only two complete failures of power on the two busses and two trunk lines connecting those two busses together. Last year, in 1929, for the first time in the history of the plant, neither one of the two busses were deenergized. There were some local disturbances which the switching and relay

equipment took care of rather satisfactorily, isolated them to one or two circuits and did not disturb either what we call north power house or south power house bus. Neither did it disturb our power supply to our main pumping station, which, of course, is a very important part of the plant. That is the first year we have gone through with such satisfactory conditions. Now, I believe you will agree with me that we can point to that experience as being a tangible result of this revamping work we have done.

Just as important as doing that work in the beginning is the making of short circuit studies and setting up a program conforming to the result of those studies, is checking the system from time to time as you contemplate additional electrical equipment, and we have done that. We undertook the installation of a large machine (large for us) last year. The installation was gone over and before we ordered the equipment to go with that machine. we made a check survey of changes that had come about by reason of this revamping work, took into consideration the additional capacity of this new generator and made a new supplementary short circuit study, and in that way were able to include many of the various pieces of equipment, new parts and newly designed pieces of apparatus which would bring the system up into such shape that it would meet the new duty imposed by more generating equipment; and so far we have, by adding some new equipment to what we had last year and years before kept our system in the shape it was in before we put this new generator on to it, and we have not had to undo, tear down or rebuild any of the revamping work we have done. I think we are fortunate in that respect. I think it is only by keeping abreast of the growth of your system by taking surveys that you are able to keep your system in such shape that the good work done in the past does not have to be undone but merely added to as more generating equipment is added.

Wray Dudley: Mr. Hussey's company is to be congratulated on what has been accomplished there. When you can keep your busses and feeder system alive and charged at normal voltage for a solid year in a steel plant the size of the one at Woodlawn, you have accomplished something of great financial value to the company.

R. J. Harry: We started about the same time as Mr. Hussey did to go into this changeover in our electric system. About 1906 we started to put in 6600 volt system, and we of course, did not have very much at that time, and as a consequence our breakers did not have frequency interrupting capacity. We are pretty well along in revamping our system, and as I listened to the papers, it looked so familiar I thought it was our own. We have a system exactly as outlined this afternoon. Four main lines running over to new structural mill, two pair of lines leading into substation and remaining at structural mills, and another pair going to some other mills more remote. Mr. Hussey mentioned about his bus being energized for a year. I think we were fortunate, as we have had our bus energized for two years without interruption.

The relay system that we have adopted was balanced current and overload. On account of the fact that we have synchronous equipment attached to our sub-stations, makes it possible to get selective action in that way and more easily than balanced power. We are right now finishing up the first section of our loop system. One sub-station was energized this week, and if we do not have a blow-up, the other will be energized tomorrow.

One thing we will have to look into, that is, installation of so much synchronous equipment. It is going to mean in a few years what the growth of our various systems is meaning now. When we started 20 or 25 years ago putting in our high voltage system, 6600 at that time, we put in breakers for their carrying capacity, not for interrupting capacity, and I feel with the installation of so much synchronous equipment, it will not be long before there will be another revamping unless that is taken into consideration and provision made for it. We are going to grounded system, and tests show it is well worth considering. We have low resistance, less than 2 ohms.

Wray Dudley: Could you give some idea of the amount of gas evolved at the time your reactor vanished.

R. J. Harry: Hardly as much as at McKeesport, but a good bit.

E. G. Merrick: The three papers presented today have illustrated very clearly how electrical transients in a large steel mill system are pre-determined and how oil circuit breakers and relays may be applied to meet such conditions, in order to give safe and reliable system operation.

The problems encountered in different plants vary greatly and it must not be deduced that the solutions will always resemble those given today, even where large steel mill systems only are under consideration. The supply and distribution of power vary greatly in different cases and each problem must be solved in a manner which will best satisfy individual requirements.

The suggestion was made that the picture, shown by Mr. Jones, of a spectacular oil switch failure be published for the enlightment of the Association engineers; my idea is that such broadcasting should be primarily for the education of the plant executives. Now-a-days most engineers appreciate that an oil circuit breaker must be able to do more than carry normal rated current; it is not always an easy matter, however, to obtain authorization to spend sufficient money to realize reliable operation under transient conditions.

Wray Dudley: It is not so much a question of educating the superintendents. It is a tremendous job to sell the executives the higher priced switches. I could not imagine anything more eloquent than that picture. I have heard many speakers discuss the breaker problem at times, but nothing could equal that picture in presenting convincing arguments for the purchase of an adequate oil circuit breaker.

H. A. P. Langstaff: Regarding the picture shown this afternoon and references to precaution on breakers, ratings, etc., these can, I think, best be summarized in a specification to the manufacturers as follows:

"Breakers should have a stand-by rating; that is manufacturers will stand by the breaker when it does what they say it will do." We put that up to some of the manufacturers during some of the Wilmerding tests. That slogan has been mentioned on

many occasions. So far as West Penn Power Company are concerned, we like all other companies, vary on the capacity of breakers applied on various circuits. There are very few cases where we have a breaker applied on a circuit, but what its rating is far beyond the capacity that can be applied over that circuit. This for several different reasons: First, standardization of equipment. There are many cases in which we have breakers applied on various voltages where the capacity of the breaker, that is the rating as mentioned or stated by the manufacturer is probably four times—possibly more than that in some cases—the duty which the breaker is able to handle. One case Mr. Jones mentioned where one breaker had five operations and one breaker had three operations and both were put back into service without inspection, brought to mind an operation we had within the last three years where a breaker installed on a 6900 volt circuit got a total of 26 operations during the day. It controlled a circuit which covered a great deal of territory. After these 26 operations it was necessary to take the breaker out of service. The tanks were taken off and straightened. The top of the breaker was taken out on an anvil and hammered into shape and the breaker was in service the next morning. That is an actual fact. There were two similar cases of where a breaker with a fabricated steel top was very badly bent and humped up in the top, and we were able to straighten it out and put it back into service.

We probably are in a different position than most steel companies in that we continually have places where we require breakers of different rating. For instance, in the station I just mentioned, where the breaker became warped and was replaced with larger capacity breaker, the lower capacity breaker was removed and used in lower capacity station. Steel companies, I believe have conditions of that kind probably to a limited extent.

Regarding operating records on breakers. We follow that up closely as indicated by this case where we had the 26 operations in one day and if the local organization don't realize the breaker has had a number of operations, we check and they are advised to see that the breakers get proper inspection. I want to emphasize the necessity of keeping a record of the total number of operations.

Reference has been made to calculating tables. We made our own calculating table which we think is as fine a table as any in the United States. You have probably read of it in periodicals. It is modified from time to time, changing the fixed resistors for each section of the circuit to conform with system changes. We have also a number of variables which can be injected into the system whenever we get changes, which is almost continually. We have found our table very valuable and necessary. The company with which I am connected, I am sure would be glad at any time to loan the facilities of our table to any company in this district in order to help solve your problems. The Duquesne Light Company, I presume, would also place their table at your disposal. Hardly a day goes by but what we use the table.

On the diagram which has been shown on the screen this afternoon, nothing was shown in connection with by-pass, disconnects, double buss, or arrangements of that nature. We in most cases use either a double bus arrangement or a combination of bus disconnects and by-pass switches whereby any breaker we have can be taken out for inspection without any disturbance to service. That I would think is highly essential in steel mills.

We have found in several cases on our customers properties, oil switches with the oil frozen and the breaker absolutely inoperative because the breaker was installed indoors but subjected to outdoor temperature. There are very few companies who do not guard against installing a breaker indoors and using indoor oil when it should have outdoor oil due to the fact that it is subjected to outdoor temperature.

Mention has been made of the grounded system. The delta system is a hard one to protect against failures of single conductors to ground. Public utilities are probably in a different category to a steel mill from that point of view due to the fact that we have a great number of quite long distribution circuits where conductors can go to ground, and it is a question how soon it will be detected. That is a hard problem to solve. We are attempting to solve it by means of ground detectors with an alarm scheme such that if the distribution system out of the substation fails to ground and not enough current flows to function the relays, we will invariably get an alarm indicating that some one of the circuits is grounded. Steps are immediately taken to find and remove the trouble.

In connection with automatic reclosing breakers, I don't know how essential it is to steel mills, but I presume it is essential in some cases to re-establish service as quickly as possible. We have some breakers on 4 KV which are automatically reclosing in 5 seconds. We are considering decreasing this time.

You have seen this afternoon a picture—concealing equipment of course—showing a severe case of trouble. In talking with some of the breaker engineers recently, I was advised that within the last year there have been more tests made on high voltage switches on high capacity systems than for the past twenty years and the thought came to me that it would have been nice if we could have had a picture here this afternoon showing the functioning of some recent breakers, where the breaker was opened and closed as rapidly as was possible to do so, interrupting quite high currents at quite high voltages with no serious disturbance whatever. In other words, contrast the picture you saw this afternoon with a breaker which will fulfill the stand-by specification and notice the development that has been made in the last few years from that point of view. I think the time is coming when a standby rating is a fact.

As to the manufacturers trying to get customers to apply the right equipment, that is a thing that works both ways. I am thinking of instantaneous low voltage relays which we have tried to get manufacturers to guard against in their application. I recently had occasion to check with one of our customers in connection with their equipment and found instantaneous voltage relays applied. Why the manufacturer should continue to supply these relays which are so unsatisfactory, I don't know. Perhaps some of our manufacturing friends can tell us.

F. E. Fairman, Jr.: We have all appreciated the excellent presentation by Mr. Wohlgemuth of the

short circuit study of an electrical system typical of a large steel mill. It is advisedly that the description "large" steel mill is used because the discussion was definitely fixed as covering problems in a major sized plant. The practical nature of the study is evidenced by the fact that several plants along the Monongahela River have layouts of this character and the general diagram of connections is not dissimilar from plants in the Cleveland, Youngstown and Chicago regions. However, the diagram in question should also prove interesting in suggesting means of attacking problems that come up in connection with the smaller plants buying power from public utilities through the media of step down transformer banks of even say 5000 KVA capacity or less. Its publication will provide very useful reference data to many manufacturing plants perhaps extending to some outside the iron and steel industry proper.

The various comments that have been elicited regarding oil circuit breakers and the interesting discussion by Mr. Jones of the Duquesne Light Company concerning high capacity testing facilities indicate that oil circuit breaker selection and application is receiving more careful consideration than ever before.

While the A. I. E. E. specification of interrupting rating has been classified as the duty at which flame is not emitted while the breaker is subjected to the 2 O.C.O. cycle there is a growing conviction, which has been substantiated in modern breaker design, that the A. I. E. E. specifications for breakers of 100,000 KVA rupturing capacity (and above) should be changed to read "without emitting flame **or oil.**" The reason that 100,000 KVA has been mentioned as a tentative dividing line is due to the proverb that you cannot eat your cake and have it too.

When a breaker has been built with the necessary construction features to be classified as "gas-tight" when operating at its rated duty, it will most probably be found that the minimum resulting design will have 100,000 KVA rupturing capacity at least. In a breaker that falls in the "gas-tight" classification there are design features that bulk very large in importance if the breaker in question is to give a good account of itself.

Welded Fabricated Steel with an Absence of Castings in the "containing" structure (that part which must withstand the internal pressure); Cylindrical Tanks with Domed Top and Bottom construction (eliminating tendency to deform under internal pressure); enclosed operating mechanism (eliminating tendency toward false reclosure due to unbalanced forces on mechanism) gas tight resilient Gaskets Well Recessed in Steel (to prevent ejection under internal pressure) separating chambers (to safely conduct any resulting gases to a gas header) and, last but not least, Ample Strokes of the order of Ten Inches or More in 15 KV plain-break designs.

As breakers of the type outlined above do not require oils with flash points as high as non-gas-tight construction requires, the same oil is recommended as is used for outdoor breakers, regardless of the location of the breaker and hence the condition of frozen oil due to low substation temperature is eliminated.

A breaker of the gas-tight design outlined above will meet its published rating and if given even half a chance in the way of maintenance will have sufficient margin of safety to give leeway of the nature that Mr. Langstaff has mentioned. It should be borne in mind that a gas-tight breaker equipped with contacts of the explosion chamber type actually reaches its best characteristics as an interrupting device when operating at or about its rated capacity. Designs of this type are primarily interrupting devices rather than gas generators, because, while recognizing that gas will always be found in greater or less quantity when an arc is drawn in oil, in an explosion chamber breaker, the problem of extinguishing that arc is met by permitting only enough gas to be generated to force oil into the arc to interrupt the circuit.

Another feature of breaker application in steel mills is the voltage rating and the creepage insulation value. Even in metal clad applications, where the bushings are to a certain extent covered and protected from dust deposit, we have limited our applications on 6600 volt systems to breakers with bushings that will stand a one minute test in excess of 40 KV. Generally speaking the 15 KV breaker is standard for 2300 volt and 6600 volt indoor applications and the 23 KV or 34.5 KV breaker for 6600 volt outdoor work. For 44 KV service 69 KV breaker has been furnished.

In discriminating between various normal 60 cycle ampere ratings in the various breaker types having 150,000 KVA rupturing capacity and above we have found that for steel mill service (with a certain few individual exceptions) 1200 ampere is the minimum rating that it is reasonable and economic to consider. The initial short circuit current values usually reach a figure that make it imperative to go to the 1200 ampere size in order to get sufficient one-second rating. Furthermore in the interests of standardization, it is desirable to concentrate on one switch size and reduce spare part storage. This reason is further reinforced by the fact that the difference in price between smaller sizes and the 1200 ampere size are usually insignificant when considered in relation to the price of a large capacity breaker.

There is an organization designated as N. E. M. A. which the principal manufacturers use to establish standardization of voltage steps, rupturing capacity steps, etc. The public utilities have a similar organization in N. E. L. A. I believe that the A. I. & S. E. E. would further simplify the application of breakers in steel mill service generally if an agreement could be reached regarding standardization of breaker types somewhat in the way that they issued a set of standard requirements for the D.C. mill type motor. Naturally the standardization of breakers is a little different problem from that of motors, but a specification for breakers of 150,000 KVA and larger capacity at 15 KV does not seem impossible at this time.

The N. E. M. A. lists the following points which the various contributing manufacturers agree to furnish regarding oil circuit breakers (in addition to the information usually given on the nameplate):

(1) Interrupting capacity.
(2) Weight.
(3) Amount of oil.
(4) Such dimensions as are required for installation.
(5) Height of oil in tank.

(6) Shape and dimensions of tank.
(7) Material of frame and tanks.
(8) Operating currents at normal voltage of solenoids or motors.
(9) Time from operation control switch to touching of contacts (average figure).
(10) Length of stroke.
(11) Temperature rise.
(12) Insulation test.
(13) Method of tank support (excludes dimensions and materials of supports).

This data (combined with the features mentioned before when discussing the gas-tight breakers) should enable the discriminating purchaser to be sure of what is being furnished to him.

A discussion of breaker application would be incomplete without some reference to current transformer selection. A first class oil circuit breaker may be rendered inoperative (in the sense of automatic protection) if the current transformers blow up on the initial rush of current during a fault. It should be borne in mind that the limitations of a circuit breaker from the short time standpoint are usually mechanical, whereas those of a current transformer are primarily thermal and hence vary as the square of the current. As a result a current transformer of proper design will usually withstand 200% of its one second rating for 0.25 seconds. This means, for instance, that on a system of say 59,000 amperes initial fault current the oil circuit breakers would have to have 60,000 amperes capacity for one second (which is the shortest time for which such values are published) but the current transformers need have only a rating of 30,000 amperes for one second. There may be individual exceptions to the above practice but generally speaking it is representative of usual applications where the largest generating units are turbo-generators not in excess of 30,000 K.W. each. It is understood, of course, that where initial current is mentioned that the term is understood to mean the instantaneous unsymmetrical value of fault current.

As regards the relay problem on a system of the kind pictured, material simplification of relaying is accomplished by grounding the system neutral. This facilitates the application of pilot wire relays and the various differential protective schemes. Extremely rapid segregation of a fault to ground can be accomplished by means of directional ground relays which can be given low time and current settings. Faults may be isolated while in the incipient stage.

In addition, grounding the neutral reduces possible voltage strain on apparatus to a value not exceeding 3800 volts to ground on a 6600 volt system. There are comparatively few sizable plants left which are not operating with the 6600 volt neutral grounded or who have not made provisions for grounding in the immediate future.

We note with considerable gratification that in the preparation of the short circuit study a grounding resistor not in excess of 2 ohms was selected. A resistor of 2 ohms or less on a system with 3800 volts to ground normally, will limit ground faults to 1900 amperes more or less, which is sufficiently reduced value to preclude the possibility of system disturbance when a ground fault occurs and yet permit the ground current to reach a value at which ground relay operation will be positive even when fairly high resistance ground faults are encountered.

From the engineering standpoint for complete protection it is preferable to have 3 current transformers in each 3 phase circuit and complete 3 element relaying whether the neutral is grounded or not. There are various schemes for evading this requirement some of which look good on paper but none of which should be permitted to get into a steel mill's relaying and protective system under any pretext on circuits rated 2200 volts and above. However, there is unfortunately, a commercial aspect to the question as well as an engineering and operating view. Sometimes this commercial aspect is permitted to dominate to the point of whittling down an installation to a bare minimum regardless of safety factors. Also wherever they will be of use we prefer to see complete relay testing facilities.

The use of A.C. undervoltage relays has been mentioned. These devices are especially important and for steel mill service should be of the induction type in reasonably dust proof cases.

F. O. Schnure: I attended a meeting of the A. I. E. E. in Baltimore last night, the subject was "Lightning." Two speakers from the local power companies gave good talks on lightning. The chairman then introduced me as "a user of lightning." I thought that was rather an erroneous introduction, unless he referred to the lightning knocking our old and underrated switches off the line.

One of the points mentioned last evening was that of installing circuit breakers of ample voltage rating. An instance was cited, where a 66,000 volt line was used for 13,000 volt service temporarily a considerable number of transformer bushings on this circuit flashed over during lightning storms. On investigation they found the lightning arresters had a flashover point of about 32,000 volts, whereas the bushings were rated at 30,000; consequently lightning spilled at the weakest point. He thought it was a good idea to have a weak point ahead of breaker equipment. Breakers should have from two to four times the voltage rating of the circuits served.

With respect to short circuit study, I should say it is impossible to apply circuit breakers to a system unless the circuit conditions are known. In 1916, we bought breakers for a system estimated ultimately to have 100,000 KVA capacity. At that time an installation of gas engines with high reactance was considered and six or 30,000 KVA eventually installed. Things went along nicely, until about 1923, when we contemplated some additions to our plant and decided to have a study made of our system. We then found, in addition to our system growing, our circuit breakers had been de-rated to about one-fourth of their rating years ago. We, of course, went to the management and convinced them that whatever breakers were bought should be of ample capacity and should replace power house breakers, the old ones being used in the mills on the new work for which they had plenty of capacity, but we could not convince them that we should have new breakers all the way through.

There is a lot of good luck connected with the operation of a power system. Those old breakers behaved splendidly until about two or three years ago when a couple let go altogether. We then had to step in and revamp our transmission system in order to get reasonable short circuit conditions. Our system is a loop system having two loops now serv-

ing a capacity of 100,000 KVA. We were fortunate in being able to divide that load up. By splitting up loads on the loops and sectionalizing the busses by installing reactors, we were able to bring our short circuit conditions down from eighty to 40,000 or 50,000 amperes which could safely be interrupted with the breakers we started out to use. We have had very gratifying results from that installation. Prior to this we were having from six to eight complete outages a year. We have now had continuous service on the power house bus for the last two years.

I want to mention a rather amusing incident in connection with our oil switch study. I was talking one day to one of our power company men who had tested switches similar to some of ours and which were rated at 40,000 amperes in 1912-16. He said he doubted if they would interrupt 2000 amperes. His attention was called to the performance of three of these switches on our system for the last fifteen years with not a blow up. He said, "I think they went out and bounced back in, some other part of the system taking the brunt of the trouble."

All these papers and discussion as well as our own experience teaches the fact that a growing power system must be watched like a hawk lest it get beyond due bounds.

James Farrington: We have installed the loop system and use reactors. They have taken care of our line and only on one occasion have we had a dead short on the 6600 line through relays functioning, and we did not have an interruption of service on our strip mill.

E. K. Read: Mr. Jones showed you a photograph of test yard at Wilmerding. I saw some of these tests. In the picture the spectators were all sitting still. My recollection is they should be moving. We had to run up hill and there was certainly a number of times when we wanted to run.

Mr. Langstaff mentioned large number of tests on high voltage breakers recently and the improvement in the behavior of the breakers because of the knowledge gained during these tests. I believe that can be brought over from high tension breakers to include lower tension breakers. On 15,000 volts and down, the performance of breakers has improved tremendously, because of similar tests. A steel mill engineer mentioned going out to look for a breaker after a fault interruption and it was gone. Early breakers were considered good if they opened the circuit even though they "died" in doing it. Now the breaker has to be good at the conclusion of two interruptions. It is only through knowledge gained on tests where large blocks of power are available that we are able to meet these demands for better behavior and performance of the breakers.

Mention was made of the tendency of operating devices until they fail. I believe the tendency in the steel industry is to try to anticipate failures. You are trying to cut the weak links out before they fail. I remember attending a meeting several years ago where a report was made of a plant that had not had a single short circuit operation by a breaker on this plant; the engineer said he felt that the expense in maintenance, he was going too, was money well spent.

The degree of maintenance of the breaker is most important as regards the behavior of the breaker. It is supposed to be in first-class condition while in service, the longer the service the worst the condition it gets into; it gets stiff in the joints, and the oil does not improve. A definite maintenance schedule is necessary. One company * maintains a card index, with a card for each piece of apparatus. The history is right there. Every time they put in new parts; every time service is rendered, it is put right there.

Mr. Greensward mentioned the possibility of applying a breaker with a 7500 volt rating on a 6600 volt circuit. I believe it is standard practice with iron and steel electrical engineers to use a breaker of the next higher voltage class, i.e., 15,000 volt breaker on 6600 volt circuits, 25,000 volt breaker for 13,200 volt circuits. This gives a safety factor beyond what the designer has provided. I believe recent designs have greater safety factors than they used to have.

It is an interesting thing to think of the problem of the designer. Insulation is a matter of distance; current carrying a matter of copper, with no steel in the wrong place, but the rupturing capacity rating of the breaker is the factor given the most weight in the selection of a breaker. How often does a breaker rupture a short circuit? As near as I can figure about one in a hundred ever has to interrupt a dead short. With some breakers that is a good thing. But the designer is asked to design a breaker which will function in a prescribed manner under conditions that occur only once in the lifetime of one of a hundred breakers, yet the rupturing rating is the part of the problem that worries the designer the most.

Wray Dudley: Mr. Bohn, is there any possibility of putting aluminum in oil circuit breakers?

D. I. Bohn: I think it would improve them greatly, and I do not see how it would increase the price.

J. D. Greensward: In regard to the safety of voltage ratings of breakers as applied to system, 7500 volt breakers should be used on 6600 volt systems. It is true that I said that, but it was used from one point of view only as I purposely left out any discussion as to the type of equipment built by various manufacturers. The reason that I said that is, that in the application of breakers in our line of work, in which we make nothing but armorclad, at the present time, there is no exposed bushings of any kind, and we feel that a 7500 volt breaker along with its switching structure is perfectly satisfactory for 6600 volt service. This should be taken account of in oil circuit breakers or any other part of the switching structure that has exposed bushings, and I think we all heartily agree with this. If there are conditions where exposed bushings should be used with a large factory of safety, the selection of open type equipment should be taken accordingly.

In the selection of breakers for any system, they should be chosen large enough to take care of future growth, if possible, as well as the present conditions. In this particular system, we had reactors that limit the current in the various parts of the system, but there is some parts, particularly on the main bus, where we believe the breaker should be picked with a large enough interrupting capacity to

* See Page 295, Yearly Transactions, 1925.

take care of the maximum condition without the reactor. This will allow a factor of safety under the ordinary conditions for a decrease in the interrupting capacity of a breaker due to poor maintenance and other things that might not have been taken into consideration at the time of buying the breaker. Always pick a breaker with a factor of safety in interrupting capacity rather than one that will just meet the calculated conditions.

C. W. Harrison: Throughout the papers and discussion I have been impressed by the fact that your problems are practically the same as ours. Our power system is very similar to the one under discussion. We have a somewhat larger generating capacity and are tied in with a large power company. In the last 15 years we have gone to 60 cycle.

Like the rest of you, I was interested in the picture of the oil circuit breaker which failed. At first I couldn't understand the stationary position of the spectators but that was explained by a later speaker. The Alabama Power Company as you know, conducts similar tests on breakers. I witnessed one such test where the breaker duplicated the performance shown in the picture here today. The local representative of the company whose breaker was on test was very prominent before the test, but very shortly after was 100 yards in the woods.

I have thoroughly enjoyed this meeting and wish to express my appreciation of the invitation that made it possible for me to be here.

Wm. R. Hamilton: As an operating engineer I hold quite a different point of view on the subject than most of the persons who have spoken. The manufacturer is interested mainly in the sale of his equipment and the design engineer is interested largely in making the layout and supervising the installation. Generally neither has much actual contact with the equipment after it is in operation, unless outstanding features are brought to their attention. I must live with the equipment from the day it is placed in service until it is replaced.

Under my supervision are breakers that are the best that can be bought today. Again we have at some smaller stations breakers that are of obsolete design and are not up to our standards for the service they are rendering, although our construction schedule calls for the replacement of all of these older breakers shortly. During trouble I do not hesitate to order the closing of any of the newer breakers, when it has opened automatically on a case of trouble, as I know the breaker will open successfully several more times the case of trouble with practically no damage to itself. On the other hand I have an altogether different viewpoint when one of the older breakers has opened automatically on a case of trouble. I am afraid to order it closed until it has been examined although service may be interrupted and then when the order is given I am wondering if the breaker will open successfully again, if the trouble is still evident. This delay certainly does not tend toward the best type of service possible.

When purchasing breakers it seems advisable to have them rated considerably beyond the systems present needs, as based on the manufacturer's ratings, even though the system may not expand to rating of the breaker. In actual service breakers often get more severe service than that specified by the manufacturer's rating and this naturally reduces the rupturing capacity of the breaker.

On the West Penn System there are no cases where we have a time interval of two minutes, as specified in the manufacturer's rating between the tripping and closing of a breaker into possible trouble. Our present average time interval on 132 KV and 66 KV breakers is one minute and on breakers of lower voltages is thirty seconds. Some breakers are closed automatically five seconds after they trip and close three times within ninety seconds, before we will believe service cannot be restored.

The time interval between the tripping of a newer breaker and closing it on a test is placed by the consumers on the line controlled by the breaker and not by the breaker itself. The delay before closing it to give any rotating equipment a chance to be taken off the line either manually by preferably a CV relay before power is restored. We are much happier when we know the breaker is rugged enough to hold up under any duty we place upon it.

The problem of closing a breaker controlling a long line across the country, and closing a breaker controlling a short feed to a furnace or some motors, or a breaker to a transformer bank, a section of bus or a nearby substation are quite different. In the first case, as mentioned by Mr. Jones, of Duquesne Light Company, the breaker will be closed as often as we believe there is a chance to restore service, with the hope sometimes of burning the trouble clear. The delay in such cases of waiting for the line to be patrolled or sectionalized are rather great. In the other cases the closing of the breaker into the trouble a number of times may do considerable more damage, and only enough tests should be made to determine definitely that trouble exists. Often it is best practice to inspect all equipment on a circuit in trouble before the breaker is reclosed. This is particularly the case when differentially connected relays operate to cause breakers to trip.

Nothing has been said about the training and coaching of the operators that operate the different stations and have charge of the operation of all breakers that are installed. This is very important although many organizations do not give it much thought. Although a lot of money is spent in designing and building a fine substation and the best equipment available is installed, very unsatisfactory service results will be experienced if the men employed to operate the station are not thoroughly and carefully trained.

Many organizations in the transition from steam to purchased power have placed the operators from the steam station in the new substation with very unsatisfactory results. Many of these old steam men cannot be taught to think "electrically." The average operator has the tendency to close a breaker into trouble too often if service is interrupted in the hope of restoring it. This generally results in possible damage to the breaker and worse damage at the trouble. This can be prevented best by detailed written operating instructions for every station covering the definite procedure to follow upon the occurrence of every likely case of trouble. Such instructions the operators should be required to memorize.

The West Penn Power Company has seen so definitely the need of the proper training of oper-

ators at consumers stations that we have undertaken this service. We then are reasonably sure that nothing on the consumer's premises will prevent the power flowing. We write the switching instructions for any switching necessary in connection with our service at all consumers stations and then we instruct personally all operators at the stations. We follow up our concentrated instructions by a visit about once every month or two to review operating matters with the operators as a precaution that our instructions are not forgotten.

The need of such coaching was brought out about two years ago when a large steel mill on the system experienced a 27 minute interruption although power was available at the station 26 of the 27 minutes. The operator at the mill had forgotten that he had definite written instructions as to just what to do during such an emergency and instead he spent most of the time attempting to get a telephone connection out of the mill.

The proper writing of operating instructions for a station is a difficult and slow task, especially if done properly and the average organization does not have a person who is capable of doing such work and who can take the time to do it. If this task can be done it will be worth the time and effort spent.

M. J. Wohlgemuth: I think Mr. Hamilton's remarks about the training of operating organization is something that all of the steel plant superintendents probably are thoroughly aware of and working to that end. It is a very important question.

Another question that it seems to me cannot be stressed too strongly is maintenance. I do not believe anything more need be said except it is very important.

The question of automatic re-closing on lines to feeders brought up by Mr. Langstaff has been applied in a few cases in steel plants. It is questionable whether absolutely necessary for the simple reason that practically every station in a steel plant, especially for main roll drives, has operators to take care of closing back in. In large substations it might be advisable to consider automatic equipment. Two plants have automatic equipment. It happens to be a substation where there is no operator. There, of course, it is very desirable.

The question brought up by Mr. Hamilton of double bus or auxiliary bus is one that has had considerable discussion among steel mill organization. I believe you will find a number of plants have double busses in generating stations and substations with single bus. There is a question as to whether it is necessary to go to double bus if you use some of the more modern form of truck-type or armor clad gear so you can change a breaker very quickly anywhere along the line. It will take not more than a few minutes at the most. If you are putting in a modern installation, I question whether double bus would be desirable. Every individual plant would have to decide for itself. Check off expenditure for double bus against possible continuity of service through the system.

I think there is no question at the present time that the over-all cost installed of steel enclosed equipment is somewhat less than if you build concrete cells and put on safety devices such as inter-locked doors, inter-locked disconnects, and go to all the fool-proof schemes you can think up; whereas you get them all with the completely enclosed factory built type.

O. E. Fawcett: I am unwilling to leave that picture on the executive's desk. Give him a good look at it and then mail it to the manufacturer. Perhaps it will do him—and us—as much good there as anywhere. In other words, gentlemen, regardless of what equipment you have, where you buy it, or how extensively the manufacturer tests it, the user provides the ultimate proving ground for the industry. Let's pass the data obtained from the exhaustive tests made on this nation-wide proving ground on to the design engineer. Obviously when we are assisting the manufacturer to iron out his difficulties, we are aiding ourselves in obtaining better equipment. There are things, some of them details and some quite serious, continually showing up on most classes of apparatus. The manufacturer is sincerely grateful for any information we are willing to give him on how his equipment functions. We of the West Penn Power Company make it a point to supply this information, and have in many cases been gratified to find our suggestions immediately incorporated in his design. This data is by no means limited to troubles which warrant a claim against the manufacturer. Repairs or revamping which we would normally do as a matter of maintenance are brought to his attention. If an oil circuit breaker opens satisfactorily under excessive duty or several times under current conditions even approaching the rating of the breaker he is informed. If the breaker throws oil, or excessively carbonized the oil, or burns its main contacts, or some of the accessories fail to function he is told about it. In order to be able to give the manufacturer this information we should carefully record all available operating information on our apparatus. This includes record of operations and their seriousness, record of inspections, of condition of equipment as found and left, any conditions out of the ordinary, etc. Then we are in a position to make up a very comprehensive history of the equipment. In case trouble occurs this history should be included with our report to the manufacturer as well as our recommendations for overcoming the difficulties. These points are almost sure to be well taken or at least will be seriously considered for this industry is, like most all others, highly competitive and the manufacturer cannot afford to ignore our suggestions for the improvement of their product. Let them know they are selling to men who are making a study of the apparatus they use and know what they want. Try it.

A. W. McAuly: I would like to inquire what maintenance men are going to do about oil in our maintenance program. We open up breakers at regular intervals, inspect the operating mechanism, clean the dirt off insulators, and so on, but some of us, at least, do not know what to do with the oil. I would like to know whether the life of oil is indefinite, or if it has a definite life, what the limits are? What factors determine the life of the oil? What sort of tests are we to make to determine whether or not we should use oil over again? Whether any accumulation of moisture would ruin the oil and anything that has to do with this question of oil?

Maintenance of oil is a problem, of course. The

best way is to take sample of oil from main circuit breaker and conduct test. Tests should be made, but the tendency is to be perhaps too sanguine on maintenance of oil, because the oil has been approved along with the rest of the breaker design, and oil will precipitate sludge under continued operation and you will find a precipitate in the bottom of the tank. Regular inspection testing oil, and purifying of oil by centrifugal devices; those things will keep oil in good shape.

K. N. Reardon: The relaying problem has been covered very well. In the power plant complete bus protection should be applied if possible. A fault there, unless quickly isolated, may cause serious damage and a total interruption of considerable duration.

Ground relays applied to a system consisting of parallel lines and loops may cause trouble in that fault current in one line of a parallel pair induces current in the other line, which circulates around a closed loop. This will cause the ground relay of the good line to operate and open its breaker. I would like to hear what the General Electric representative can recommend as a remedy. The pilot wire protection is the only one mentioned tonight which effectively solves the problem.

I wish to make a plea for adequate test facilities at the switchboard. I believe that neither the manufacturer nor the purchaser look at them from the viewpoint of the man that must check relays and hunt trouble in secondary wiring. The switchboard is too often accepted by the purchaser without criticism. A thorough study of the wiring drawings should be made by one familiar with the equipment and experienced in checking relays and wiring thereto. It should not be necessary to remove wires from any instrument to carry on a routine test.

It seems to me that supervisory control has a great application in steel systems such as we have studied tonight. Are there any plants now so equipped, or with such equipment in prospect?

F. E. Fairman, Jr.: I would rather see a system completely relayed with as complete relay protection as we can get on them, but nine times out of ten when representative of power company visits a small industrial plant he has seen a board purchased under severe conditions. The engineer of the purchasing company has not had much to say because some authority has been taken away and the company bought cheaper equipment. There should be complete relay testing facilities and wherever possible those are included, but, of course, we have no control. From the standpoint of the engineer complete protection should be furnished in every instance, whether grounded neutral or not. But there is a commercial aspect as well as engineering.

L. F. Kennedy: There is definite trouble on parallel lines, particularly lines that run parallel to each other but not actually connected in parallel at both ends. Where you have parallel lines, a balanced ground neutral takes good care of that condition, but use of separate relays is quite apt to get into trouble.

E. H. Coxe, Jr.: "Nothing has been said about trip-free control for circuit breakers. It may have been assumed that it should be a part of every breaker installation. By trip-free I mean with an electrical or mechanical device to prevent holding the breaker closed against a short circuit. There may be a time when you would not want your breakers to be trip-free, namely when there is a probability of a man closing a breaker on a short circuit when standing close to it. If the breaker hasn't the stand-by rating defined by Mr. Langstaff, it would be preferable to have it non-trip-free, thereby making it remain closed even though a fault exists on the line being fed through this breaker. In this case the back-up breaker, probably that tying the feeder bus to its source of supply, would clear the trouble.

G. B. Dodds: Regarding Mr. Kennedy's answer to Mr. Reardon's question concerning the remedy for relay operation caused by induced current in transmission lines under ground fault conditions, and with transmission line connections which provide a path for the circulating currents, I do not believe that Mr. Kennedy's solution of balancing the transmission lines will overcome the difficulty in all cases. We have several transmission connections of this nature protected by balanced protection, and we are unable to prevent the opening of one line of a pair of lines.

In connection with the settings of protective relays in customers' substations, where these customers are fed from a utility company or are interconnected with them, it is very important that the customer's relays on his feeders or transformer bank breakers will select properly with the relays on the utility company's high tension breakers, in event of trouble on the customer's equipment.

This is essential not only to avoid interrupting other circuits in the customer's own station, but also to prevent interruptions to other customers which may be supplied from the same high tension line. In addition, it sometimes requires an appreciable length of time to re-establish service after the utility company's breakers have opened, as the reclosing of these breakers should only be done under the direction of the load dispatcher or system operator of the utility company, and considerable time may be lost in making the necessary telephone calls and locating the trouble.

To prevent this failure of selection between relays owned and maintained by the customer, and those owned and maintained by the utility company, the settings on the relays should be determined by the requirements of both parties, and after having once been determined, the current or the time settings by the customer's relays should not be increased without consulting with the public utility's company.

We had a rather unusual occurrence a couple of years ago when one of our customers had some trouble on his 2300 volt bus, and our high tension line breakers opened instead of his 2300 volt transformer bank breakers. The steel mill electrician in charge did not think that this was as it should be, but evidently did not want to make a complaint to the power company until he was sure it would happen again. He performed the following test before we had an opportunity to investigate the trouble.

He established a solid short circuit on his 2300 volt bus purposely by means of a short piece of 4/0 cable and with this short circuit on the bus and our high tension line breakers closed, he closed his 2300 volt transformer breaker and again our high tension line breakers opened instead of the 2300

volt transformer breaker. This evidently satisfied him that the relay settings were not as they should be, and he notified the power company as to what he had done and what he had found and asked for correction to be made.

In this particular case we were able to increase the time settings on our relays so as to select properly with the customer's relays but this is not always possible and depends upon what other customers may be connected in the same high tension line. In all cases where any difficulties are experienced in regard to relay operations, the utility companies are only too glad to have their men work in conjunction with the customer's men to overcome the difficulty.

N. A. Hooper: The installation of auxiliary bus and spare breaker is of importance not only as an additional protection in case of trouble, but also for maintenance purposes. The proper maintenance of equipment is nearly as important as its proper selection. A spare breaker allows any other breaker to be removed from service and inspected or repaired immediately.

F. E. Fairman, Jr.: A discussion of this nature would not be complete without reference to supervisory control methods. There are two types applicable to two different classes of steel mill service. For radial feeder layouts with many substations having only a few breakers in each, there is the cable type supervisory control involving control cables running to each substation from the supervisory control board. This gives continuous direct control and indication of each controlled circuit breaker. For the control of substations involving large numbers of breakers in each there is the synchronous selector type of supervisory control involving only four wires running from the supervisory control board through the different substations. The operation of this system gives automatically machine switched control of each circuit breaker and indication of each controlled device based on its last operation. Polarized relays are used in the last mentioned scheme.

N. A. Hooper: We have eight stations controlled by supervisory and we find those stations very reliable. We find that the reliability of the equipment is greater than the reliability of operators, and we have placed the supervisory control system under the supervision of the system operator, as the system operators are more highly trained, more highly paid and much less liable to make mistakes than operators we can afford to keep out in the sub-stations. We have found the supervisory control system to be reliable and efficient.

E. G. Merrick: It is often evident that consideration of the switching and relay problems of any system ends with the main generating station or substation; what takes place at points of distribution in adjoining mills or factories is apparently overlooked.

In many cases this distribution equipment is subject to short currents comparable to those realized at the main station, but the protection provided is entirely inadequate.

Wherever it is possible to do so economically, I believe that it is desirable to limit the short circuit current in the secondary distribution circuits to values which can be handled by breakers of relatively small rupturing capacity; such limitation in turn increases the factor of safety of the many industrial type devices, such as motor starters, etc., which are necessary for mill operation. I would like to suggest that the Association give this matter some definite consideration.

Graphical Carbon Balance of the Blast Furnace

By T. J. ESS*

The desirability of obtaining a carbon balance of a blast furnace is generally recognized, particularly among combustion and power engineers, due to its usefulness as a check on gas production, blast volume, and furnace practice in general. The accompanying charts were developed to facilitate the acquisition of this information.

A brief explanation will render the use of these charts simple. The data required includes the gas analysis, coke rate of the furnace, percent of carbon in the coke, and heat values of the gas and coke. The last two items can be calculated from analysis. It should be mentioned that the data used in making a balance should be averages over a fair period of time, as a month. Daily figures from a blast furnace are likely to be erroneous and misleading.

Beginning, on Chart I, with the coke rate, project vertically to the percent of carbon in the coke, then horizontally to intersection with the line representing the ($CO_2 + CO$) content of the gas. This latter line is determined by projecting from the CO_2 scale through the CO scale, then following the slope of the lines representing the sums of these two. Again projecting vertically, the volume of gas produced per ton of iron is given and continuing to the percent of nitrogen in the gas, thence horizontally, we determine the volume of air furnished per ton of iron.

On Chart II, projecting vertically from the volumes up to the coke rates, thence horizontally, gives the volumes of gas and air per pound of coke. Vertical projection from the intersection with the line representing the heat value of the gas passes through the scale giving B.T.U. contained in the gas per pound of coke consumed, and intersection with the line of heat value of the coke leads to the percent of heat value of coke represented in the gas.

For example, as shown by dotted lines in the charts, with a gas of 13.5% CO_2, 27.0% CO, 2.0% H_2, 57.5% N_2, a coke rate of 1780 pounds per ton of iron, 87.5% carbon in the coke, 95 B.T.U. per cubic feet of gas, and 12,450 B.T.U. per pound of coke.

On Chart I, from 1780 vertically to 87.5% carbon in coke, then horizontally to line representing (13.5% CO_2 + 27.0% CO = 40.5), then vertically to 122,000 cubic feet of gas per ton of iron. Continuing vertically to 57.5% N_2, then horizontally to 89,000 cubic feet of air per ton of iron.

* Comb. Engr., Republic Steel Corp., Massillon, O.

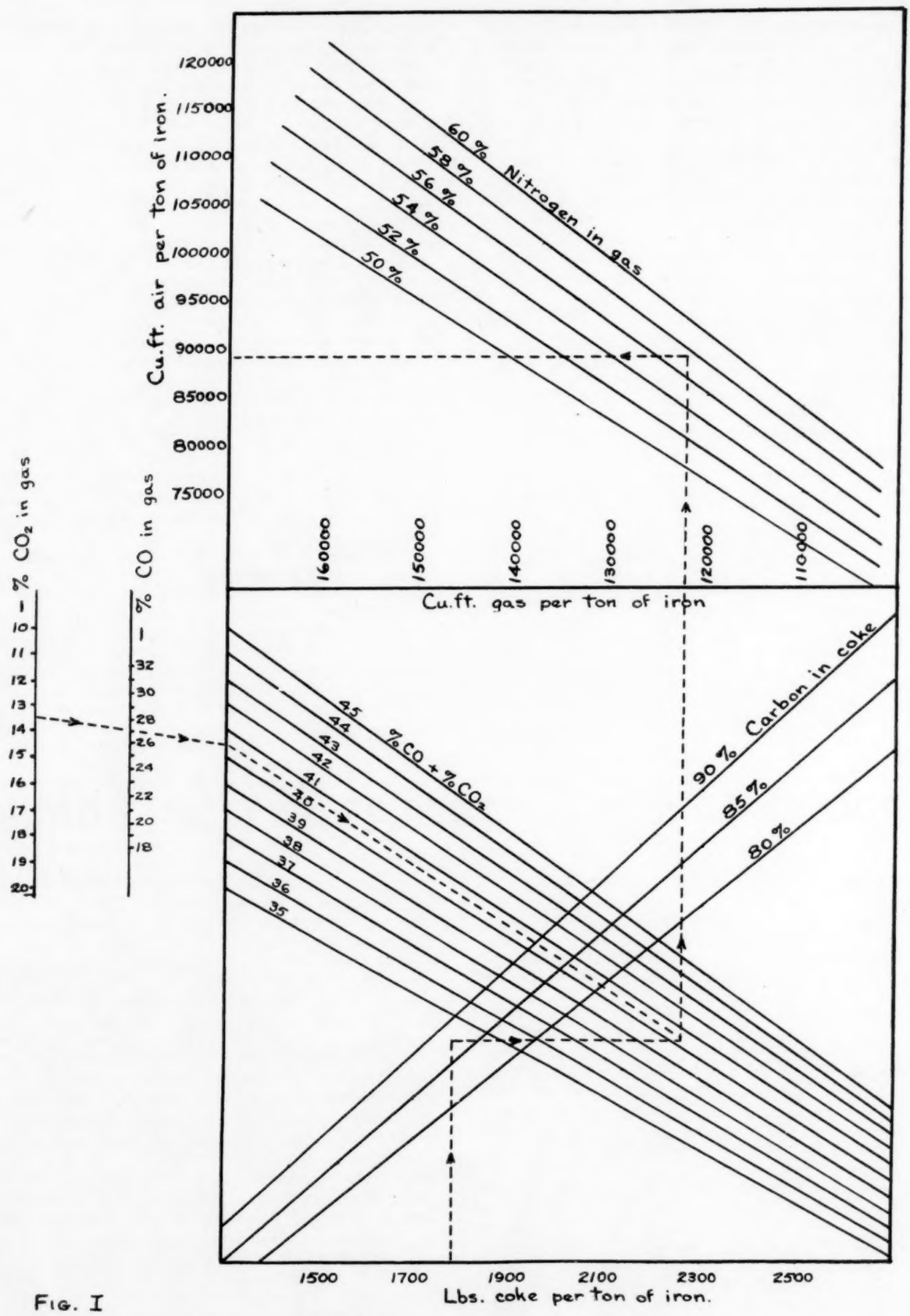


FIG. I

GRAPHICAL CARBON BALANCE OF BLAST FURNACE.

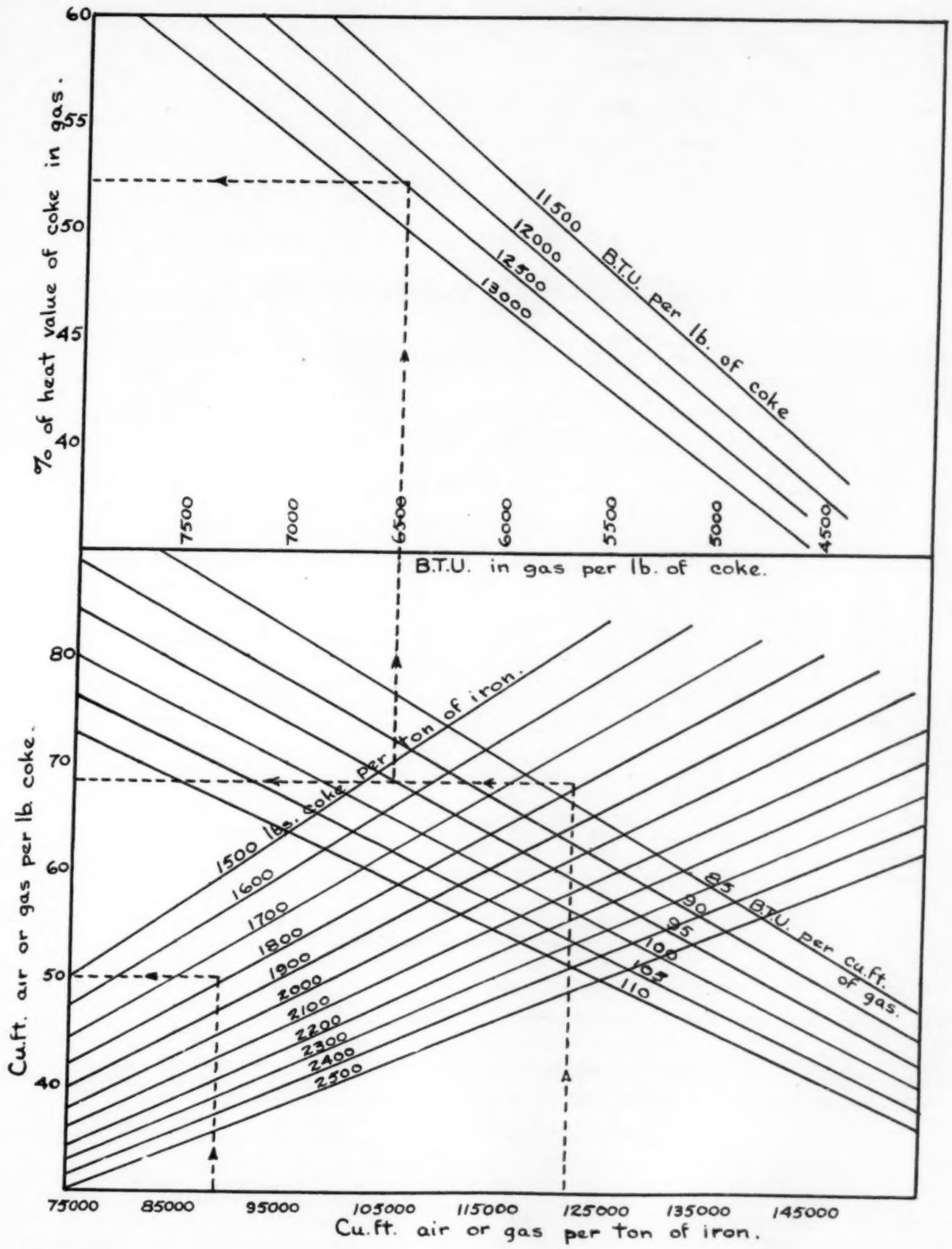


FIG. II.
GRAPHICAL CARBON BALANCE OF BLAST FURNACE.

On Chart II, vertically from 89,000 cubic feet of air to 1780 pounds coke rate, then horizontally to 50 cubic feet of air per pound of coke. Likewise, from 122,000 cubic feet of gas vertically to 1780 pounds coke rate, then horizontally to 68.2 cubic feet of gas per pound of coke. From the intersection of this last horizontal with the line of 95 B.T.U. per cubic foot of gas, vertically to 6500 B.T.U. in gas per pound of coke, and on to 12,450 B.T.U. per pound of coke, thence horizontally to 52.2% of heat of coke represented in gas.

If this same balance is worked through analytically, the results are in substantial agreement, well within slide rule limits. It will be noted that the limestone is not considered in the calculation, nor is the carbon in the iron, flue dust, etc. These items roughly balance each other, and are commonly omitted even in mathematical calculations, as such refinement is hardly justified in the face of the accuracy of the basic data used. For the purposes for which the carbon balance is commonly used, this graphical method will be found sufficiently accurate.

Convention Comments

A. I. & S. E. E. CONVENTION AND EXPOSITION SPECIAL RAILROAD FARES TO CLEVELAND, OHIO, JUNE 15th TO 19th, 1931

The Central Passenger Association carriers have authorized the following special fares for round trip on the Certification Plan, from their territory, which embraces practically all points of residence of our members and friends of the Association. These fares are also available to dependent members of your family as well as yourself—we hope a large number will avail themselves of these rates so that we will be accorded the same courtesy each succeeding year.

(a) Round trip tickets will be sold at one and one-half fare (with minimum of $1.00) for the round trip, on IDENTIFICATION CERTIFICATE ONLY —tickets will be good only via same route in both directions. Round trip tickets will be sold from June 11 to 17 inclusive, and before being honored for return passage, return portions must be validated (in space provided thereon) at Cleveland, O., by ticket agents' dating stamp at the regular ticket offices of the lines over which the ticket reads into Cleveland from June 15 to 25 inclusive, and when validated, tickets will be good for return, leaving on any day within final limit; passenger **must,** however, reach original starting point within limit shown on ticket but in no case later than midnight of June 25, 1931.

(b) One and three-fifths fare for round trip on Identification Certificates, return limit **thirty days** in addition to date of sale. Selling dates and other conditions to apply same as in paragraph marked (a).

(c) For tickets via diverse routes—see your local ticket agents for explanation.

Children of 5 and under 12 years of age, when accompanied by parent or guardian, will, under like conditions, be charged one-half of the fare of the adults.

You must present and surrender to the ticket agent the Identification Certificate issued on account of our activities, and these can only be secured through our Association so please advise John F. Kelly, Managing Director at once if you contemplate taking advantage of these special rates, and how many certificates you will need so we can order same at once

JOHN F. KELLY,
Managing Director, A.I.&S.E.E.,
Empire Building, Pittsburgh, Pa.

Railroad Associations granting these rates: Trunk Line Association, New England Association, Southeastern and Southwestern Associations, Western Passenger Association, Trans-Continental Passenger Association; Canadian National and Canadian Pacific Railways in part.

SUBJECT OF PAPERS TO BE PRESENTED AT A. I. & S. E. E. CONVENTION AND EXPOSITION

Electrical Developments, 1930-1931.

Standardized Symbols for Control Apparatus.

Illumination of Steel Plants.

Motor and Control Equipment for Cold Strip Mill Drives.

Twin Motor Drives.

The Practical Side of Metallurgical Heating Application.

A description of a recent installation of Combustion Control Apparatus on Open Hearth Furnaces.

The Application of Health Lamps to the Steel Industry, with respect to Health and Efficiency.

Electrical vs. Mechanical Devices for Combustion Control Apparatus for Open Hearth Furnaces.

A tabulation of Anti-Friction Bearings installed on Roll Necks in the Iron and Steel Industry.

Anti-Friction Bearing data in connection with Electric Overhead Traveling Cranes.

Arc Welding.
Lubricants for Roll Necks.
Lubricants for Roll Tables.
Lubricants for Cranes.
Lubricants for Machine Tools.
Lubricants for Turbines.
Lubricants for Motors and Generating Equipment.
Testing of Lubricants.
Inspection Trips.

Eight Papers in connection with Wire and Wire Products.

Judging from present indications our June Exposition will be one of the largest and best of our years of experience and firms taking part will certainly benefit from the many valuable contacts afforded.

The June convention issue of the Iron and Steel Engineer will contain plans, programs and papers to be presented at the Convention and Iron and Steel Exposition.

STEEL MILL LUBRICATION CONFERENCE

AUSPICES

LUBRICATION ENGINEERING DIVISION

Association of Iron and Steel Electrical Engineers

WEDNESDAY, FEBRUARY 18, 1931

WILLIAM PENN HOTEL **PITTSBURGH, PA.**

PROGRAM

2:00 P. M.

DEVICES AND APPLIANCES

for

STEEL MILL ROLL NECK LUBRICATION

The following Lubrication System Manufacturers presented papers covering Roll Neck Lubrication Equipment:

Keystone Lubricating Company, Philadelphia, Pa.
The Hodson Corporation, Chicago, Ill.
Lubrication Devices, Inc., Battle Creek, Mich.
Hills-McCanna Company, Chicago, Ill.
Pennsylvania Lubricating Company, Pittsburgh, Pa.
United American Bosch Corporation, Springfield, Mass.
Trabon Lubricating Equipment Company, Detroit, Mich.

Each paper was based on an actual Steel Mill Installation and the following points as outlined below were covered in each Manufacturer's paper:

Type of mill and material rolled on mill.

Location of the System; that is, how far is the system from the stands?

Are pipes carrying lubricant underground, overhead, etc.?

Are pipes insulated?

How long has system been in operation on this particular installation? Is it automatic or manually operated?

How is system operated—by air, water or electricity?

Is the Lubricating System power, independent or is it dependent on the regular plant source of supply?

What arrangements are provided for the quick change of rolls?

Description of the distribution of grease on necks.

Very brief description of control of lubricant at neck.

How is lubricant put into lubricating system from manufacturer's container?

Effect of climatic conditions on lubricating system.

Power savings effected by lubricating system.

Lubricating savings.

Savings in bearings.

Savings in maintenance and upkeep of equipment.

Safety features.

Improvement of product.

Saving in man hours in application of lubricant.

Cleanliness.

Devices and Appliances for Steel Mill Roll Neck Lubrication

R. C. McDaniel, Sales Engineer, Keystone Lubricating Co., Pittsburgh, Pa.
W. D. Hodson, President, Hodson Corporation, Chicago, Ill.
A. J. Jennings, Vice President, Lubrication Devices, Inc., Battle Creek, Mich.
H. J. Anderson, Engineer, Hills McCanna Co., Chicago, Ill.
Maurice Reswick, Mechanical Engineer, Pennsylvania Lubricating Co., Pittsburgh, Pa.
George P. Dempler, Western Pennsylvania Representative, Trabon Lubricating Equipment Co., Pittsburgh, Pa.
M. J. Helmes, United American Bosch Co., Springfield, Mass., and J. Guy Griffith, United American Bosch Co., Pittsburgh, Pa.

By R. C. McDANIEL*

The Keystone Lubricating Company approached the subject of Automatic Application of Roll Neck Grease through the necessity of developing a method or system which would handle a semi-solid plastic type of lubricant. It is difficult to discuss many of the savings features outlined in today's program without making reference to the primary cause of such savings, namely the lubricant.

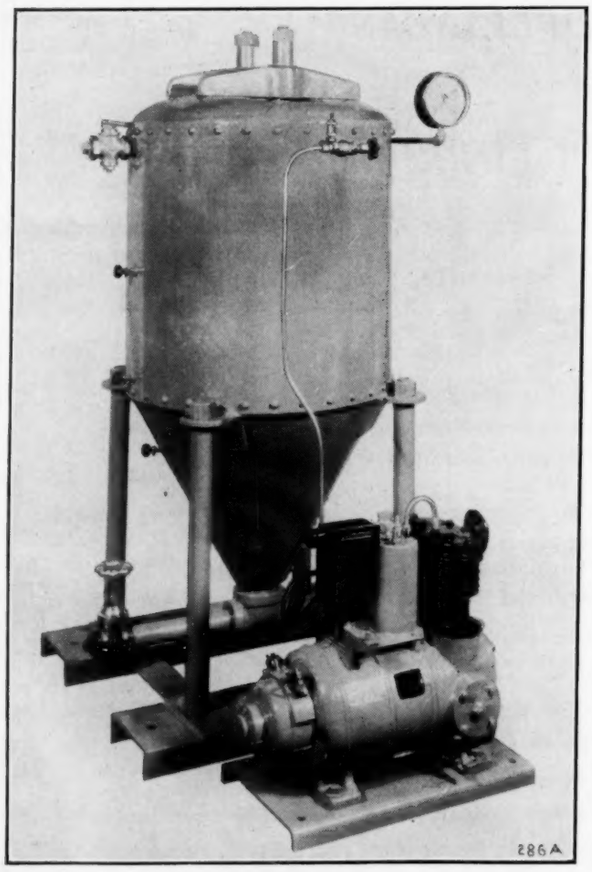


FIG. 1.

The principle of Keystone Manually Operated Lubricator with a Manifold, and a separate pipe line to each bearing was the basis of experiments leading to the development of the Keystone Pneuma-Lectric System. This equipment consists of three essential parts, namely:

The Pneumatic Lubricator (Grease supply).
The Rotary Distributor (Grease Distribution).
The Electric Timing Device (Control of Operation).

Grease under pressure from the lubricator is always present in the hollow rotor of the distributor. When the timing device makes contact the distributor motor operates the rotor and when the master port in the rotor registers with an outlet port in the stationary cylinder, grease passes through and enters the pipe line leading to the neck. In this manner the master port contacts separately each and every outlet port, giving each neck the individual benefit of the header line pressure. There is a grease gauge mounted in the header line just ahead of the rotor. The fluctuation of the hand on the gauge indicates when the rotor is rotating, the master port coming in contact with each individual pipe line leading to the wiping box indicates that each line is open. If the hand on the gauge does not fluctuate at each opening, then the pipe line is plugged. There are no valves to adjust in this system.

To date permanent installations of the Pneuma-Lectric System have been made on a total of 53 mills including strip, plate, bar, blooming, merchant mills, rod and sheet mills. Trial installations which are constantly in progress will add to this number from time to time.

Type of Mill and Material Rolled on Mill.

As a subject for this paper we present details on an installation on a 40" Blooming Mill, rolling blooms and bars down to 4x4" and 3¾x3¾" up to 125' lengths.

Location of the System; that is, How Far is the System from the Stands?

The Pneumatic Lubricator (450 lbs. grease capacity) is located about 35' from the stand.

Are Pipes Carrying Lubricant Underground, Overhead, Etc.?

The 2" Iron Header Pipe is run underground from the lubricator to the rotary distributors which are located on the mill stand.

Are Pipes Insulated?

A 3/8" steam line is run parallel with the grease line and both pipes encased in pipe covering.

* Sales Engr., Keystone Lubricating Company, Pittsburgh, Pa.

How Long has System Been in Operation on this Particular Installation? Is it Automatic or Manually Operated?

The installation has been in service six months, and is automatically operated.

How is System Operated—By Air, Water or Electricity?

The Lubricator is automatically air operated under a pressure range of 225 to 250 lbs. per sq. in. The Rotary Distributor is motor operated.

Is the Lubricating System Power, Independent or is it Dependent on the Regular Plant Source of Supply?

A Motor Compressor Set is a standard part of the Pneumatic Lubricator unit.

What Arrangements are Provided for the Quick Change of Rolls?

When changing rolls the wiping boxes are removed without disconnecting any pipe, as grease proof rubber hose is inserted between the pipe and wiping box. The wiping box is held in place against the neck and against the fillet by a strap slotted on both ends attached to end of wiping box and carrier.

Description of the Distribution of Grease on Necks

On the neck we employ a wiping box. This is usually made of cast bronze and must be designed to conform with the curvature and length of the neck. Grease is admitted to the box through a core hole which extends from the outer end to a point beyond the center where it turns toward the neck and enters and fills an open pocket or chamber and forms a contact with the neck. By admitting the grease to the fillet side of the center of the box, assurance is had that the fillet will receive an ample supply. By the use of the wiping box you do not need to change the design of the brasses or the wobblers on the mill to allow a pipe connection. This application can be applied to any type of mill.

Very Brief Description of Control of Lubricant at Neck.

The quantity of grease delivered to the neck is regulated by the frequency of operation of the rotary distributor. The Electric Timer may be adjusted to operate the distributor motor at intervals of 10 minutes or greater, depending upon the needs.

The average installation requires delivery of grease at ½ hour intervals.

How is Lubricant put into Lubricating System from Manufacturer's Container?

Grease is pumped with a pump or shoveled from the shipping drum into the 450 lb. lubricator through the 15" top opening.

Effect of Climatic Conditions on Lubricating System.

If the installation is in an exposed position it is necessary to provide heat protection, by a coil under the grease container.

Power Savings Effected by Lubricating System.

A saving of 30% in power was effected and is being maintained.

Lubricating Savings.

Grease consumption was reduced approximately 66%, resulting in a saving of nearly $12.00 per day.

Savings in Bearings.

Previously the bearing wear was 1/16" to 1/8" per day and roll adjustments had to be made each day. Now only a scant 1/16" take-up is necessary after a week's run. This indicated at least a 700% increase in bearing life. Resulting savings are made in maintenance and upkeep expense.

Savings in Maintenance and Upkeep of Equipment.

By the proper application of lubricant on the roll necks and set intervals of the system, you are able to eliminate the fire crack necks which all mill operators know is a costly upkeep, also a longer life of brasses and less adjustment to the mill.

Safety Features.

The complete Pneumatic System eliminates a man from applying the lubricant to the necks when the mill is in operation.

Improvement of Product.

The regular application of the correct lubricant minimizes friction and bearing wear and allows a more uniform gauge. Likewise, due to a reduction in idle hours, production is definitely increased.

Saving in Man Hours in Application of Lubricant. Cleanliness.

The service of one man was saved after installation was placed in operation.

Through the application of the correct amount of lubricant, and its proper distribution over the neck, plus the protection afforded by the wiping box, there is no surplus to run down over the mill housing. This greatly improves the general conditions about the mill.

By W. D. HODSON*

The Adams-Schuette System is made up of a group of parts consisting of an Electric Control Panel, a Solenoid Valve, an Air Moisture Separator, a Pressure Grease Tank and the required number of Lubricator units. The accompanying illustration shows a group of items as listed above, including four Lubricator units, providing for the lubrication of sixteen bearings.

The functioning of this Lubricating system is extremely simple. Compressed air is used as the motive power for the grease, and electricity for determining the cycles of application and the operation of the Solenoid. The grease is delivered from the Pressure Grease Tank by compressed air at 80 to 100 lbs. pressure per square inch, through large lines (from 3" to 1½" in diameter) to the lubricator units, the main grease passage of which is ¾" in diameter with short connecting passages of ½" diameter to and from each individual valve, with a ¾" outlet to the grease line. The grease does not pass through any gears or mechanism to agitate it. Neither is it forced through any small gears.

The body of the Lubricator Unit is made from a solid forging and consists of four double acting pistons. The grease cylinders and pistons are hardened, ground and lapped to close limits. The air cylinders are brass lined. The only moving parts are the pistons, therefore nothing liable to wear out

* President, Hodson Corporation, Chicago, Ill.

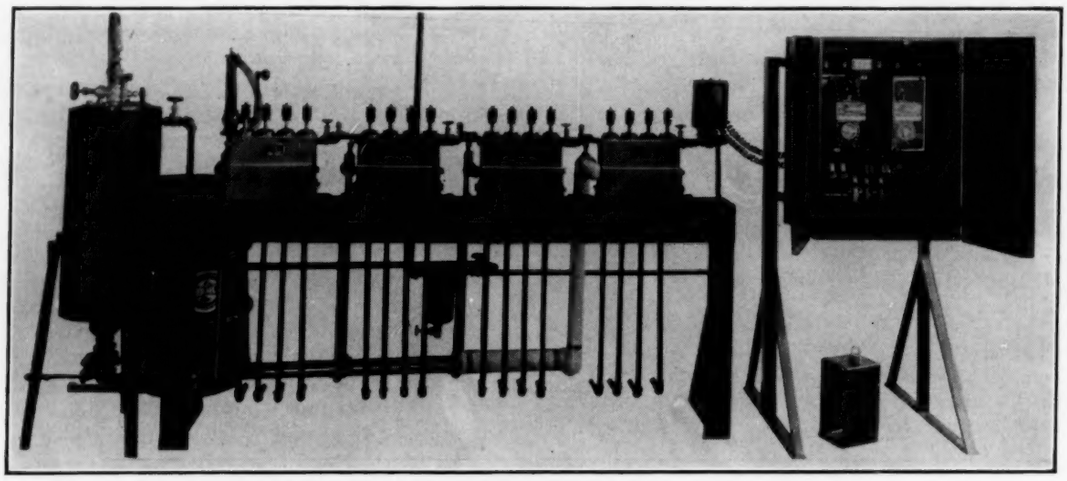


FIG. 1.

other than the air cylinder leather cup washers, which with reasonable care provided for the purpose, should require very infrequent replacement, if ever.

The heavy mill type Lubricator Units are made in four sizes for grease line pressures per square inch of 1000, 1250, 1500 and 1800 pounds, delivering at each full stroke of piston one-quarter, one-half, three-quarter, and one ounce respectively.

Undoubtedly automatic mechanical application will permit the use of comparatively lighter bodied lubricants for some purposes, but heavy duty equipment still demands protection of tough heavy greases against pressure and shocks. There is practically no limit to the body of plastic grease which can be used with this system.

The outstanding features of this Lubricating System are:

1. Extreme simplicity of design, and sturdiness of construction.
2. The application of an adjustable measured amount of grease, from a few drops to the maximum capacity of each valve.
3. At regulatable periods from .05 minutes to practically any period up to 24 hours.
4. Of the particular kind of lubricant best suited for each individual bearing.
5. Because of the large passages in the lubricator unit, compounds with a large per cent of tallow, suitable for heaviest neck pressures, may be used.
6. By means provided for a number of different greases and in differing amounts of .04 to one ounce or more.
7. To each individual bearing separately, wholly independent of any other.
8. Delivery of the grease to the bearings without passing it through gears, agitating or otherwise breaking down its body.
9. At long distances through pipe lines.
10. Compressed air adjustment, permitting of increased or decreased grease line pressures.
11. A sustained pressure on the grease lines for adjustable periods.
12. Two operating units—the plant air line and an individual air compressor.
13. Connection with a compressed air line at any point provides means for operating a complete system or as many groups in which they may be split up. The several groups may be operated by connections at different points with the plant air line.
14. The amount of lubricant and the periods of application, being under the control of the operator by the turn of a nut or dial, without interference with the operation of the System or equipment lubricated.
15. The action of the valve stem provides a sight feed indicator for each individual valve.
16. The System, all under the same control, may be split up into several units, any of which may be closed off or opened up as operating conditions require.
17. Where variable application periods are desired, or when at times lubricant is needed at long periods only, by inserting a hand operated three way valve in the air line, any section of a full automatic system may be arranged for manual or automatic operation at the will of the operator.
18. All the parts of the System may be located where they can be readily cared for and adjusted as necessary, at points where the operators are not liable to be injured.
19. The close grouping of the Lubricator units and the Pressure Grease Tank makes it a simple matter to enclose them so as to maintain a uniform temperature.
20. The extremes of demand, distance or service, may be met with the same System. As an instance, bearings at the top of a skip hoist, and bearings in inaccessible locations under a furnace, may be lubricated with the same System, each with their particular kind of lubricant.
21. An installation may be extended at any time, by adding the required additional lubricator valves, without interfering with the operation of the original installation.

The following data was secured from an installation of our Lubricating System on a 40" Blooming Mill:

(1) Type of mill and material rolled on mill.

40" Mesta blooming mill—32"x32" ingots to 10"x10" blooms—smaller ingots rolled to 7"x8" blooms.

(2) Location of system.

Approximately 15 feet from roll stand.

(3) Are pipes carrying lubricant underground, overhead, etc.?

All overhead.

(4) Are pipes insulated?

No.

(5) How long has system been in operation? Is it automatic or manually operated?

Installed with new mill in July, 1930. System is automatic.

(6) How is system operated?

Air as motive power for grease. Electricity for timing and operation of solenoid.

(7) Is the lubricant system power independent, or is it dependent on the regular plant source of supply?

Dependent.

(8) What arrangements are provided for the quick change or rolls?

Not important on blooming mills as rolls are not changed frequently, and in our case the bearings need not be removed. However, a union is provided at end of hose connection at bearings.

(9) Description of the distribution of grease on necks.

Wide and deep grease grooves.

(10) Very brief description of control of lubricant at neck.

By changing stroke of plungers with adjusting nuts and by changing time intervals of operation of the plungers.

(11) How is lubricant put into system from grease manufacturer's container?

This depends upon grease. If grease is light enough to keep level in the container, a barrel pump can be used.

(12) Effect of climatic conditions on lubricant in System.

Nearly all greases stiffen up in cold weather, requiring considerably more pressure to force them through the lines.

(13) Power savings effected by lubricating system.

Don't know, our mill being engine-driven. There surely is some saving as well lubricated neck turns easier than one not so well lubricated and perhaps poorly lubricated at times.

(14) Lubricant savings.

Don't know but rather expect an increase due to better lubrication.

(15) Savings in bearings.

We expect an increase of 2½ times the tonnage rolled with the bearings now in the mill over previous practice. This means we shall roll 100,000 to 125,000 tons on one set of bearings.

(16) Savings in maintenance and upkeep of equipment.

In our case 16 seems to be a repetition of 15, except that we include lubrication of the window liners with the roll neck system. Our liners show practically no wear in seven months' mill operation, and we expect them to last three or four times previous practice.

(17) Safety features.

This is quite an important point, as the greaser was always in danger of being burned by flying scale or being injured by the manipulators when crossing from one side of the mill to the other.

(18) Improvement of product.

None.

(19) Saving in man-hours in application of lubricant.

With a single stand this item of course is small. However, the greaser does have more time to give attention to the tables and other units.

(20) Cleanliness.

In our case, cannot claim much difference, as our job was pretty clean before.

By A. J. JENNINGS*

The outstanding advantage of practically all types of automatic pressure lubricating systems, as applied to Rollneck bearings, is that they provide the high pressure delivery of lubricant directly to the bearing surfaces to be lubricated.

The advantages of this type of application, when compared to the use of stiff greases packed on the necks by hand where the temperature of the neck must be relied on for lubrication, is at once most obvious and it is felt that the direct application of lubricant between the surfaces to be lubricated is perhaps the greatest single factor in giving the rather remarkable economies obtained from the use of automatic pressure lubricating systems.

The delivery of lubricant directly to the bearing surfaces provides a lubricant film where it is most needed and when this is combined with the delivery at regular intervals of an additional definite quantity of lubricant, a practically constant film is maintained and metal to metal contact reduced to the very minimum.

Under these conditions, it is not difficult to understand why the life of rollneck bearings is increased many times and power consumption materially reduced through the use of automatic lubricating systems.

When all of the lubricant delivered to the bearings must first pass between the surfaces to be lubricated before it can escape, it naturally follows that waste is eliminated and lubricant consumption is usually reduced considerably over the method of hand packing the necks.

With a constant lubricant film being maintained between the bearing surfaces, particularly when an adequate supply of lubricant is delivered to the thrust, a more free running mill is obtained and the necessity for bearing adjustment reduced to the minimum. All of which will tend to give a lower power consumption per ton and should release additional power to increase daily tonnages.

THE FARVAL DUALINE SYSTEM

In general automatic pressure lubricating systems will permit the use of softer lubricants than it is possible to use when the necks are hand-packed. However, it is impractical to use one universal lubricant for all types of mill bearings and serious consideration must always be given to the selection of a lubricant which is best suited to the actual conditions of service.

* Vice President, Lubrication Devices, Inc., Battle Creek, Mich.

Having determined, through actual practical tests, the best lubricant for the bearing condition, then a method of feed or application should be selected which will provide the positive delivery of this lubricant in the most practical and reliable manner.

Our Measuring Valve will successfully distribute any type of lubricant that can be pumped through the supply line to the valves and because these valves are always located as near to the actual bearing as is practical to install them, positive control of the lubricant is obtained right up to the bearing itself. This insures the full pressure delivery of lubricant to each individual bearing or point of application.

These valves are adjustable to one-fifth of their maximum capacity; thus providing great flexibility and wide adjustment to accommodate all conditions of service.

Each valve is also provided with an indicator stem which furnishes a visible indication of the successful operation of each individual valve.

Two main supply lines are connected to each valve and the full diameter of these supply pipes is available through each valve, eliminating any restricted passages from one valve to the next.

Both of these supply lines are filled with lubricant and the hydraulic pressure for the entire system is supplied by one motor-driven screw type grease pump. This pump has but two moving parts —contains no valves, and its discharge is pulseless.

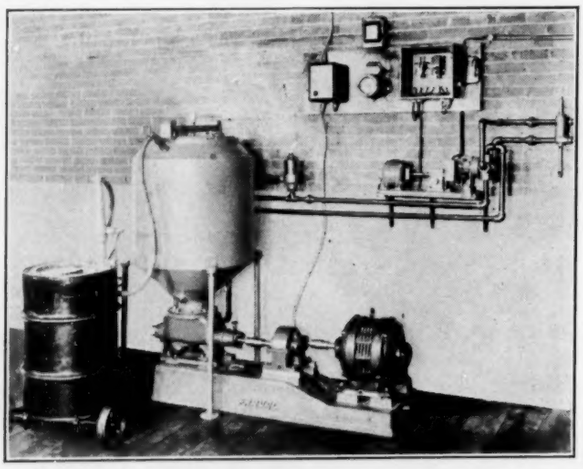


FIG. 1.

Fig. 1 shows a typical Farval central station, the electric time clock mounted on the panel being connected to the contactors in the control box through which the motor on the four-way valve is started and stopped.

You will note the large 550 pound reservoir on the grease pump, which may be either filled from a standard barrel pump as shown or the cover removed and grease put into the top. Suitable air connection is provided to permit the use of air pressure on the top of the Follower Plate in the reservoir to assist priming the pump with the heavier greases.

You will also note the high pressure heavy duty relief valve, which provides a by-pass to prevent the building of excessive pressures in the system.

The delivery of lubricant under high pressure to both supply lines is controlled through an electrically operated four-way hydraulic reversing valve. An electric time clock controls the delivery of current to the motor which drives the four-way valve and thus the time clock directly controls the frequency or cycle of the operation of the system.

When the four-way valve has indexed to the desired position, the cam on the main shaft operates the push button on one of the limit switches to make a contact which starts the motor on the grease pump. When the motor on the grease pump is started, the circuit to the small motor is broken and the four-way valve stops.

In one position the pressure coming into the four-way valve passes through to one of the main supply lines and the other main supply line is opened to the relief or return line to the reservoir.

The final shut-off of the central pumping unit is accomplished through a control valve located at the end of the line. The delivery of high pressure to this control valve breaks the motor pump circuit and thus stops the pump. By locating the control valve at the end of the line, high pressure delivery of lubricant throughout the entire system is insured before the pumping unit is shut off.

The pressure at which this control valve will operate is adjustable and may be set to give the desired pressure throughout the complete system before the valve will open to permit lubricant to enter. When pressure is applied to one line, grease enters the control valve, moving its piston in the opposite direction. There is no pressure on the other line and the lubricant is thus discharged from this valve back into the relief line. When the piston stem engages the roller on the limit switch, the circuit to the motor on the grease pump is broken and it is thus stopped.

The entire operation of our electrically-driven system depends upon the same source of power as is required to drive the mill and by connecting the central pumping station to the main mill contactor, the system automatically starts and stops with the mill itself.

It will be noted that full pressure is first delivered throughout the system before reaching and operating the control valve to shut the pump off.

INSTALLATION ON A 40" BLOOMING MILL

The following detailed information covers our Dualine installation on a 40" Blooming Mill, which rolls Blooms for a 28" Rail Mill, Billets for the Alloy Mill, and Slabs for Tin Plate. This unit has been in operation since February, 1930.

This system is electrically-operated, fully automatic, with Time Clock control. The unit is tied into the front and back Blooming Mill Main Table Contactors so that when the current is turned on to operate the Tables, the system is automatically turned on at the same time and of course is idle when the current is turned off from the main Mill Tables. No compressed air or other auxiliary sources of power are required for its operation, it being electrically-driven throughout.

On this particular installation the central pumping station is approximately 75 feet from the Blooming Mill. Also on this installation the two main supply lines have been looped back to the central pumping unit and the control valve located at this point, which gives a total distance of 186 feet.

The supply lines are of 1" diameter pipe, being located on the floor level from the central station to the stand. Upon reaching the stand they are run

vertically as high as the top roll bearing and then horizontally across the stand to the opposite side and from there back to the central station, following the same lines for return.

A ¾" Steam Line is laid parallel to and between the two main supply lines about 1" from each of them. The lines are not wrapped or insulated in any way, but are laid in a trench with a suitable steel plate for a cover.

Experience has shown that it is very advisable not to wrap the steam lines and the grease lines together because excessive temperatures are produced which tend to fry out the grease. In fact, the heat is only turned on in extreme weather or after a shut-down to provide the softening of the grease where it contacts the pipe and thus reduce the skin friction at this point. Once the mill has been started and the system operated a few times, the steam may be turned off.

As a matter of fact, due to the discharge of only a few ounces of grease each time the system is operated, the two main supply lines really constitute a reservoir of grease rather than a system of distribution. The two main supply lines should not be confused with a system of circulating oil through pipe lines, because with the small amount of lubricant discharged with each operation, the central pump becomes in reality merely the means for applying pressure throughout the entire system.

The central pumping station, with control valve and electrical equipment are all located in a steam-heated brick house, which is of sufficient size to accommodate two drums of grease. By having the spare containers of grease in this house at room temperature, the handling of the grease and the filling of the reservoir is greatly facilitated. On this particular installation, the lubricant is transferred from the drum to the reservoir by the ordinary hand-operated barrel pump.

The use of a triple thread quick union provides a simple method for disconnecting the flexible hose from the bearings to assist in quick roll changes.

Three individual connections are provided to each lower roll bearing and three to each top roll bearing. Two connections furnish lubricant to the radial surface of each bearing and one connection supplies lubricant directly to the thrust collar.

It has been found on both Blooming Mill and Merchant Mill installations that very much superior results are obtained when a separate measuring valve and lead is used to discharge lubricant directly to the thrust collar.

Where the thrust collar is lubricated by carrying a groove over from the radial surface, if the load is greater at the thrust than it is at the radial surface, the lubricant will follow the lines of least resistance and will not supply adequate lubrication to the thrust.

On a Merchant Mill installation it was found that the life of the bearings was increased from days to weeks where a separate lead was run to the thrust as compared to delivering lubricant to the radial surface only.

In general, the climatic conditions do not affect the operation of the lubricating system until there is a sufficient drop in temperature to affect the consistency of the grease. It has been found that with the average grease, the temperature must get to 50° F. or less before there is a material change in the consistency of the lubricant.

It has further been found that if the change in temperature occurs while the mill is in operation, it does not affect the operation of the lubricating system. If, however, this temperature drop occurs while the mill is idle, the grease becomes much stiffer and additional pressure is required for proper distribution.

However, the method of running the steam lines, as above outlined, will eliminate all difficulty that might be experienced with climatic changes. At least, insofar as the Farval System is concerned, where the lubricant is delivered under high pressure throughout the entire unit.

ECONOMIES

Power Savings.

Due to the variation in the kinds of materials rolled on the 40" Blooming Mill installation it has not been possible to obtain reliable data on power savings. However, since greatly increased bearing life is only obtained through the direct reduction of friction, it is apparent that there must be a material reduction in the power consumption in proportion to the increased bearing life.

Lubricant Consumption.

When the necks on this 40" Blooming Mill were hand-packed, the lubricant consumption averaged four barrels per month and with our Automatic Dualine System installed this grease consumption has been reduced to 2½ barrels per month.

Increased Bearing Life.

The average life of the bottom roll bearings on this Blooming Mill was from three to five weeks when the necks were hand-packed and the lower bearings always wore out on the thrust collar before the radial surface was worn sufficiently to require replacement.

After the installation of our system with bearings grooved, as outlined, and with a separate lead to the thrust collar, the life of the lower roll bearings has been increased from a maximum of five weeks to a total of six to eight months.

The first set of bearings ran four months and were then taken off because the grease grooves as originally provided only permitted one-half of the total wear on the bearing before reaching the bottom of the groove. At the end of this time, new lower roll bearings were installed and at the end of a four-months' operation the new bearings showed ½" of wear of a total 1" available, which would clearly indicate a possible total life of eight months. The tonnage rolled on this mill averages about 45,000 tons per month.

Reduced Maintenance.

The average monthly cost for bearing babbitt and labor of bearing changes with the hand-packed necks average some $200 per month. By increasing the life of the bearings from five weeks to six to eight months, the direct savings in bearing maintenance amount to some $2,000 per year. Another important economy obtained through the use of the automatic lubricating system on this Bloomer is to be found in the fact that no roll breakage has occurred through bearing failure since the system was installed.

Since this installation is on a Blooming Mill and not on a Finishing Mill, no noticeable improvement in the product was apparent. However, they did obtain a much freer running mill, and the need for bearing adjustment was reduced to the very minimum.

All the former labor required to hand-pack the necks is eliminated, but since this installation covered one Blooming Mill only, no reduction in the number of oilers was possible.

Cleanliness.

By eliminating waste of lubricant through the direct application of a measured charge to the bearing surfaces themselves, the mill is much cleaner when compared to hand-packed necks where each roll change puts a quantity of grease into the sewer.

Safety.

With the elimination of the necessity for stopping the mill to hand-pack the necks and because control is obtained and maintained at the central pumping unit, complete safety is provided and all hazard from this operation eliminated.

Bearing Costs

Bearing costs will vary greatly on different mills according to the method used in lubricating, type of lubricant, grooving of bearings, type of babbitt used, and size of the bearings as compared to the job they are called upon to do. The general run of Blooming Mills will cover a monthly output from 40,000 to 90,000 tons.

The bearing costs will vary from $1,800 to $6,000 yearly. This wide cost range is brought about by the above conditions.

Low cost per ton for bearings is the ultimate aim and one which plants in general endeavor to reduce to the minimum. The cost per ton will vary from $.002 to $.015.

It is evident from the above that the savings which automatic lubrication will show will have a very wide range and will depend upon the particular mill to which it is applied and upon the previous conditions of that mill. It is therefore fully within reason to expect from 400% to 1200% increase in bearing life.

The resulting bearing costs should be approximately $.001 per ton in most all cases. Where the costs were high before, the savings shown by automatic lubrication would naturally be greater and where the costs were comparatively low, the savings shown by automatic lubrication would necessarily be less. The point to be considered is that automatic lubrication will tend to equalize the wide variation in bearing costs and at the same time, should bring this cost down to the minimum.

Labor Savings.

Direct labor savings can be shown through automatic lubrication in some cases through the elimination of a man. This of course is influenced by the organization operating the mill.

Where lubrication is being given the proper attention, it naturally takes the best part of one man's time. Where lubrication is considered merely a necessary evil and the man lubricates when he has time, the result is usually reflected in the bearing costs.

It cannot be said that a man can be eliminated in every case through the installation of automatic lubricating systems but where the man taking care of this work devotes most of his time to it, he can be eliminated or released for other duties.

By H. J. ANDERSON*

The purpose of this paper is to briefly describe the design and operation of the Hills-McCanna (Anderson Mill Type) Grease Pump and its application for the handling of light or heavy bodied grease to roll and pinion necks of Steel Rolling Mill equipment, as well as other types of heavy duty machinery where grease lubrication is required.

The entire question of applying force feed methods to grease lubrication is too new to give a wealth of statistics on mill operations and economies. Some may be better equipped than we are in this regard, as our time has been largely spent in developing a Pump for handling heavy greases as efficiently as we can the light ones.

Quoting approximate figures on grease savings, tonnage records and general increase in mill efficiency we will leave to others as our information on these subjects has been unofficially given and leaves too great a leeway for the play of our imaginations. Our knowledge centers largely around problems of pump installations and the difficulties to maintain operations under conditions that by admission have been the hardest to lick.

The handling of light greases offers little difficulty, but to pump heavy bodied grease requires a sturdy unit with plenty of power behind it—an automatic unit, precise, yet simple in operation and dependable in performance. The Hills-McCanna (Anderson Mill Type) Pump operates as an independent unit by means of a direct connected electric motor mounted on the same base with the Pump. However, practically any type of drive available may be used; such as belt, ratchet or chain and sprocket. Being positive in its action, no dependence is placed upon hydraulic, air or spring pressures to maintain delivery.

A positive mechanical valve prevents slippage and enables the Pump to operate at full efficiency against any pressure up to 5000 pounds per square inch. While such pressures are greater than a Pump would ordinarily be required to work against, it is indicative of the capacity of the Pump. Grease is introduced into the feeding system by means of a displacement pump operating the mechanical valve, which is opened on the suction stroke and closed prior to the discharge stroke. A distributor head with feeds, or leads, is directly connected to the discharge side of the Pump.

The timing of grease delivery to each bearing is provided through the indexing of the distributor cylinder, which indexing is taken care of by means of a ratchet attachment which functions on the suction stroke of the Pump and remains fixed during the discharge stroke; after which it indexes to the next feed and continues in rotation. Each feed is under

* Engineer, Hills McCanna Co., Chicago, Ill.

pump pressure only during discharge and the bearing pressure holds lines full of grease during the balance of the cycle, insuring immediate grease delivery on each indexing.

Delivery lines are attached directly to the distributor head and lead to the connections on the equipment and bearings. A steam heating element is installed on the bottom of the grease hopper casting directly above the intake valve. This facilitates handling heavy greases in cold weather. A guard is placed just above the outlet of the grease hopper to prevent introduction of foreign matter into the Pump. A relief valve, which can be adjusted to predetermine pressures, is provided in the pumping unit itself, to operate, should excessive pressures be encountered.

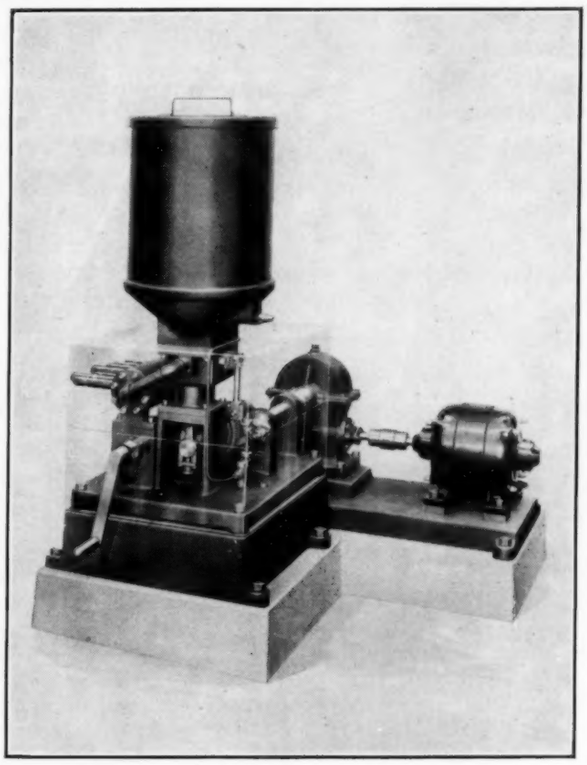


FIG. 1.

Regulation of the amount of grease delivered is taken care of by a simple adjustment on the pump stroke mechanism. This adjustment can be varied from the delivery of approximately .625 ounce per stroke to approximately 1.25 ounces of lubricant per stroke for each feed. The time per cycle or elapsed time for a complete revolution of the distributor varies from 3 minutes 26 seconds to 40 minutes, according to gear ratio and adjustment.

Grease hoppers for these Lubricators can be furnished for most any capacity and the lubricant can be added to these containers by the use of a barrel pump, or by hand, depending upon the consistency of the lubricant used. Where greases that have a tendency to channel are used, a follower is provided in the grease hopper; where extremely heavy greases are used, connections in the hopper cover for air lines are provided for the purpose of applying air pressure to the top of the follower to keep the lubricant constantly feeding to the displacement pump. When auxiliary air pressure on the grease in the hopper is necessary, 15 pounds of air pressure is sufficient for proper operation. An indicator connected to the follower is provided to indicate the level of the grease in the container.

The piping used to carry the grease to the points of lubrication varies from ¾" to 1¼" standard pipe —depending upon the consistency of the grease being used. The lines may be run either overhead or underground, as is most convenient. Insulating of the lines depends upon the consistency of the grease used; and also upon the location of the installation from points of lubrication.

Grease lines are connected to the bearings by a flexible steel hose. The grease is forced under pressure through an opening in the bearings into grease grooves, or pockets, provided on the surface of the bearings—thereby distributing lubricant to body and fillets of roll necks. Other methods of applying grease to roll necks are by the use of wiper blocks—also in many cases lubricant being applied directly to an exposed section of the roll necks.

As long as grease is moved through pipes, they of necessity have to be removed prior to roll changes. This is a disadvantage we cannot overcome, but try to minimize by simplified connections at the bearing.

All feed adjustments are made at the Pump. We believe this to be the proper place as it is our endeavor to keep the lines as free of auxiliary appliances as possible. The more obstructions in the line the greater the chance for clogging and the care of extra equipment in close proximity to the rolls is an unnecessary hazard. It is, of course, desirable to locate this type of installation as close to the points of lubrication as is possible in order to reduce line friction.

The construction of our Mill Type Grease Pump is compact and sturdy. All parts under stress and wear are made of cast steel. Bearings are bushed to give close alignment and smooth operation. An auxiliary booster is provided to fill the lines or give additional lubricant to bearings should it be needed as, for instance, after a shut down. This booster is an integral part of the Pump, but operates independently and at the option of the operator.

To illustrate some very interesting results obtained from one specific installation—one of our eight feed, motor driven Grease Pumps has been installed on an 100" plate mill, lubricating roll necks. This Mill is of the three-high continuous type with top and bottom rolls measuring 33" and roll necks 24"x 18"; rolling slabs of approximately 950 pounds into plates of 3/16" gauge and 96" wide. Frequently slabs up to 13,000 pounds rolled to gauges of 1" and up and of various widths are handled by this Mill. We are pointing this out to show the tremendous roll pressures that must be taken into consideration in this particular plant. However, the exact roll pressures are unknown.

Our Grease Pump is located approximately 30' from the roll stands in the depression table drive pit about 10' below the floor level. Three-quarter inch standard pipe is used for lubricant feed lines to the bearings. These lines are not insulated. While only four bearings of this Mill are being lubricated the eight feed lines from the Grease Pump are dovetailed together to form four individual feed lines to the four bearings being lubricated on the Mill. The grease lines are connected to the bearings by a

flexible steel hose. The grease is forced under pressure through an opening into pockets provided in the bearings—thereby distributing the lubricant to the body and fillets of roll necks.

It has been reported by this particular plant that this installation has increased the life of the bearings more than 300%; as well as reduced the consumption of lubricant nearly 50%. It has also improved the product which they are rolling by eliminating chatter marks on the plate—thereby indicating a free-running Mill, eliminating frequent adjustments and constant shimming up of the bearings. This reduction in friction reduces the consumption of power. The amount is at present unknown, but is certain to show a lower power cost per ton.

Other installations in Blooming Mills, Cold Rolled Mills and Universal Plate Mills show similar interesting results.

We will not dwell on the safety factor that force feed lubricating offers. Freedom from spilled grease due to carelessly applied lubricants; elimination of the hazard of accident due to hand lubricating methods and many other causes, are too well known to need amplification.

Material grease savings are possible, but the greatest factor in favor of force feed lubrication is improved lubrication due to regularity of delivery and the application of grease at the point needing lubrication regardless of bearing pressures.

We wish to thank the Association of Iron and Steel Electrical Engineers for their invitation to present this paper.

By MAURICE RESWICK*

In recent years there has been a marked change in industrial lubrication practice in the direction of more efficient lubrication through automatic devices, and the Pennsylvania Lubricating Company has not only kept in touch with all latest developments in this field, but has also developed and put on the market a number of centralized systems of its own manufacture which are at present in successful use on various types of machinery in the steel industry.

For the lubrication of roll necks, we present our Type 700 Lubricating System. This is a centralized, automatic, high pressure, positive acting lubricating system, on the displacement principle, which delivers grease directly from the drum into the bearings in a definite quantity at frequent intervals without exposure to mill dirt.

Construction and Operation

A diagrammatic arrangement of this system is shown in Fig. 1 at the right, while at the left, a section through one of the lubricator units is illustrated.

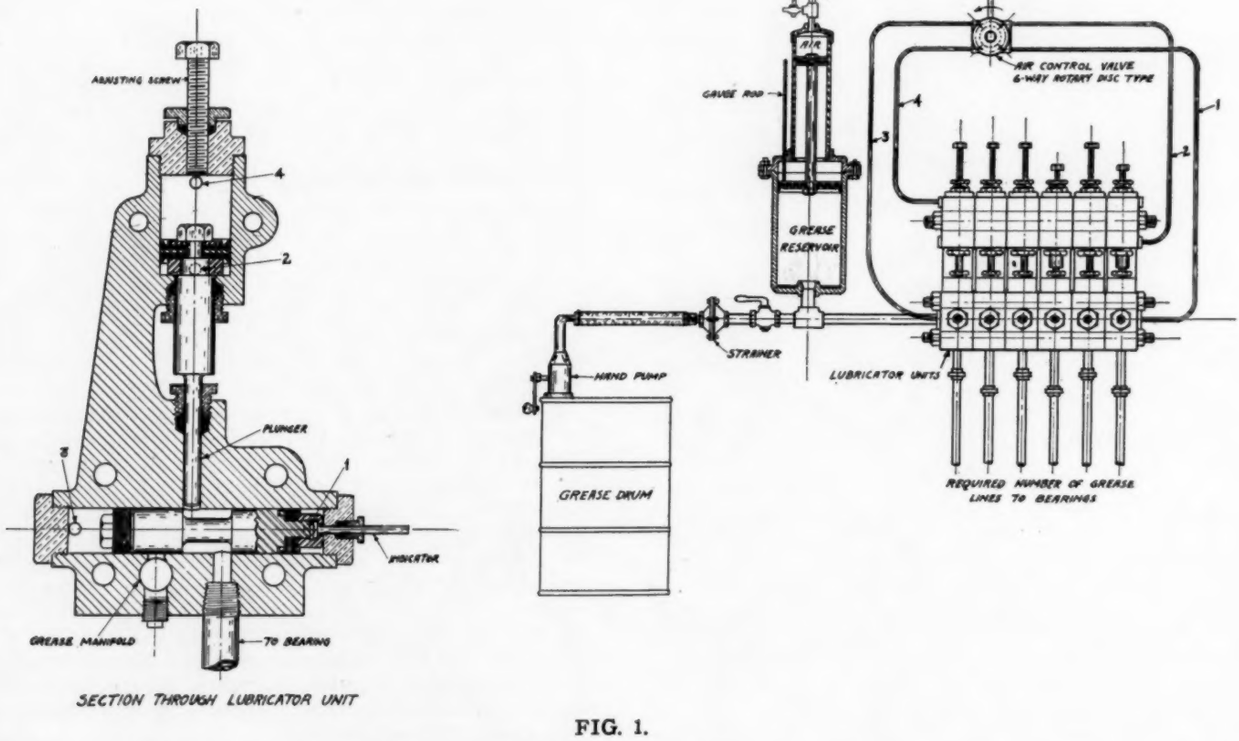


FIG. 1.

The grease used is generally received in standard drums having a 2" pipe opening at the top, into which a barrel pump is screwed, and the grease is pumped by hand through a flexible hose and through a strainer into the Grease Reservoir until it is filled, as indicated by a rod gauge. When very heavy greases are used, which cannot be readily pumped from the drum, the grease reservoir may be filled by hand. The grease in the reservoir is maintained

* Mech. Engr., Pennsylvania Lubricating Company, Pittsburgh, Pa.

at a constant moderate pressure just sufficient to cause it to flow through the manifold leading to the battery of lubricators, from which it is delivered intermittently to the bearings at high pressure.

Compressed air is used as the flexible operating medium, controlled by a 6-way disc type rotary valve. This valve is connected up through proper gearing to some revolving part of the machine to be lubricated, or it may be operated by an independent small motor through a suitable high-ratio double-worm gear speed reducer, electrically connected to the main motor, so that in either case lubrication takes place only while the mill is running. An Air Control Valve operated by a ¼ H. P. motor.

In this system a separate grease line is run to each bearing from as many lubricator units as may be required. The individual lubricators are assembled together with all grease and air manifolds in register, and are held together by studs and nuts somewhat like the sections of a common steam radiator. Additional lubricator units may be added to an existing system as desired. There are only two moving parts in each lubricator; a one-piece piston and plunger, and a cylindrical slide-valve.

The cycle of operation of the battery of lubricators, as controlled by the automatic rotary air valve, is as follows:

First: Air on pipe line 1—slide-valve moves to the left, or backwards, closing grease outlet port and opening grease inlet leading from a common grease manifold.

Second: Air on pipe line 2—piston moves up, and grease is admitted into space displaced by plunger.

Third: Air on pipe line 3—Slide-valve moves to the right, or forward, closing grease inlet port and opening grease outlet.

Fourth: Air on pipe line 4—piston comes down, and plunger forces grease to the bearing.

This cycle is repeated with each revolution of the disc in the air valve, and as the rotation of the air valve may be easily controlled and regulated, it is obvious that the bearings may be given a "shot" of grease as frequently as may be desired—anywhere from once every 30 seconds to twice an hour. The amount of grease delivered at each cycle can be further regulated by means of the adjusting screw on the top of each lubricator unit, or the flow of grease may be shut-off entirely on any unit without affecting the operation of the others.

Outstanding Features:

There are no troublesome springs, ball checks, or check valves of any kind in the operating mechanism.

The proper operation of the system may be observed at all times. The cylindrical slide valve is machined to a close fit, and has an effective area of over 1¼ sq. ins., which means that with an available supply of 100 lbs. per sq. in. air pressure, the force acting on the slide valve at either end is over 125 pounds. An indicator is provided to show the movement of this valve.

The grease is not subjected to a **constant** high pressure. In the grease reservoir the pressure is from 25 to 50 lbs. per sq. in., depending on the density. It is only when the pistons in the lubricator units come down that the pressure is momentarily raised to the required pressure. The maximum pressure is determined by the relative areas of the piston and the plunger, which have a ratio of 18 to 1 in the standard design, capable of developing 1800 lbs. per sq. in. on the grease. Still higher pressures may be obtained by changing the ratio of these areas. However, it should be noted that this high pressure is entirely **potential,** and will develop only when there is a corresponding resistance. In regular operation the pressure on the grease is normal, being equivalent to the combined pipe line and bearing resistance, and any excess pressure is absorbed by the elasticity of the feed lines.

The pistons and plungers are outside packed, and there is no danger of the grease being by-passed where it may cause trouble. Note that on the upward stroke of the piston the effective area is reduced by the enlarged section of the piston rod, which relieves the operating mechanism from unnecessary strains, and yet provides a positive means of operation without depending on the pressure of the grease in the reservoir or tank to lift the piston against the friction of the packing and the leather cups, particularly since the grease under comparatively low pressure must act on the small area of the plunger.

The grease follows a simple path to the bearings through ample and free passages and not through constricted orifices or past ball checks held against their seats by springs under high compression. By eliminating these obstructions the system readily handles heavy greases without danger of separation, breaking up of original structure or clogging up of grease passages.

No complicated electrical devices are used, and the construction of the air control valve—the "heart of the system"—is very simple, being entirely mechanical and easily understood by those in charge of the lubrication of the mill.

Performance

The system presented here is an improved development of a similar system which has been in use in the steel industry on a variety of applications since 1926 on seamless tube Piercing Mills, Tube Rolling Mills, 18" Structural Mills, and other rolling machinery.

Because this is a system of the "centralized type," with the operating parts grouped together some distance away from the heavy machinery which it lubricates, it is generally installed in an out-of-the-way place where it may be readily inspected at all times and where it is not liable to be damaged by the movement of loads when roll or bearing changes take place.

It is entirely automatic in operation, but it may also be operated manually in an emergency by providing an auxiliary small hand-operated air valve placed in parallel with the automatic valve. The lines from the lubricator units to the bearings may be run either underground or overhead, and in all existing installations it was not found necessary to provide any steam heating on the feed lines, although it is advisable to locate the operating mechanism in an enclosed room wherever possible. The pressure developed by the lubricator units is sufficient under all normal conditions to force the grease through the lines, unless the inlet to the bearing becomes clogged up, in which case this may be observed by failure of the particular unit to operate until the condition is corrected.

Generally, the available supply of compressed air in the plant (60 to 110 lbs.) is sufficient to operate the system, but, if desired, an inexpensive small air compressor may be installed when the regular air supply cannot be depended upon for some reason.

Quick-detachable quarter-turn hose connections are generally used for connecting the feed lines to the bearings, so that there is no delay in disconnecting the system from the bearings when changing rolls. It was found that ordinary air hose is quite suitable for flexible connections, as the pressure in the grease lines near the bearings is rather small, and the standard grade of air hose is coated inside with a special rubber composition which resists the deteriorating action of oil and grease.

Savings Effected:

Through the use of this system, in its original form, it was found that the life of bearings was increased from two to twenty-five times. Bronze bearings have been replaced to advantage with babbitt-lined bearings in many cases.

An appreciable saving in power is shown by the fact that no cooling water is used on certain bearings which could not be operated formerly without a steady stream of water running on them. On a Structural Mill, rolling a variety of shapes, the stream of water was cut down to a fraction its former flow when the necks were lubricated by hand. On one machine ammeter readings showed a saving of 25% in power at full load and 12% at idle load.

Improvement in product is also reported since it becomes possible to keep the mills in alignment better when rolling round or shaped sections. In one department the millwright crew was reduced by one-half, and one oiler is taking care of the work formerly done by two oilers. Periodic shut-down of the mills for hand lubrication was also eliminated, and this is quite an important item where the cost of an idle mill is figured between $200 and $1000 an hour.

Consumption of Grease:

It is obvious that with an automatic system, feeding grease to the bearings under pressure in a measured quantity which may be easily regulated, the most economical point is reached which will assure effective lubrication. Where bearings are under-lubricated, due to failure to properly pack them while the mill is in operation, the consumption of grease is found to be somewhat greater, but where most of the grease is being washed away by the stream of cooling water into the scale pit, the consumption of grease for proper lubrication will be found to be less.

The relative cost of grease consumed in an automatic system as compared with hand lubrication, while an important item, should not be considered as a deciding factor. The benefits resulting in savings of maintenance and increased operating efficiency, together with reduced power consumption and improvement of operating conditions on the mills, are far more important.

Safety and Cleanliness:

The hazards involved in lubricating a mill by hand, where the oiler has to climb over slippery machinery, are well known, and an appreciable proportion of accidents in the steel industry are chargeable to this cause. By centralizing the lubricating system in an out-of-the-way place, this hazard is removed. A noticeable improvement in the cleanliness of the surroundings of a rolling mill is observed when a centralized system of lubrication is installed.

In entering the field of lubricating appliances, as a means of better serving its customers, the Pennsylvania Lubricating Company recognizes the fact that in order to render unbiased engineering service, devices as marketed by other manufacturers cannot be disregarded. For this reason the policy of our company as regards the recommendation of any particular system is altogether unbiased, as its business is primarily to manufacture and sell high grade greases and to co-operate with all concerned in the correct application of these greases. Special conditions or cost considerations on some particular installation may be met more satisfactorily in a lubricating system of other manufacture, in which case the best system for the purpose will be recommended. In no case will the adoption of a system of its own manufacture be advocated by our company without giving the manufacturer's of other systems an equal opportunity to demonstrate their claims. The demonstration of the principle of automatic lubrication and the use of the right kind of lubricant is of first consideration, while the sale of lubricating appliances is of secondary consideration.

By GEORGE P. DEMPLER*

The demand of increased production of tonnage in steel has naturally brought about the design of higher speed and heavier mills for rolling steel, and the age old design of roll neck bearings and methods of lubricating them have not kept pace with the increase radial loads on roll necks and other steel plant bearings, and the higher percentage of delays charged to bearing failures, scored necks, and even broken rolls, has caused mill operators to seek relief in mechanical lubricating devices.

The mill operator who thinks he can readily go out in the open market and purchase a standard lubricating system to apply to his mill with old type bearings and handle the solid greases, is due for disappointment.

Since any machine is only as good as its bearings, the operator should first decide to make a study of the bearings and roll necks, and be prepared to improve their design to receive the application of a lubricating system, and use the kind of lubricant the system is capable of handling, and our experience has been that almost every mill or machine presents its peculiar problem, and each piece of equipment must be carefully analyzed and treated separately.

Our many years of experience in industrial lubricating devices has enabled us to design, manufacture, and place on the market the Trabon metering valve and accessories for complete systems that can be applied to most machinery at the least expense and with maximum efficiency.

Since the birth of our Lubricating System, we have made hundreds of installations throughout the

* West Penna. Rep., Trabon Lubricating Equipment Co., Pittsburgh, Pa.

industrial field on all kinds of industrial equipment with phenomenal success. Nevertheless the many invitations to go in for lubricating roll necks has been approached by us very cautiously. We have analyzed many cases carefully, and we find that the application of our metering valves to roll necks is ideal; very simple and inexpensive systems can be designed, due to its flexibility.

One large Steel Company in the East is using our system on their tables, shears, straighteners, and various other steel plant equipment, and found that the systems all paid for themselves in the saving of lubricant alone in a short time. This prompted them to try this application on their roll necks on their 112" Plate Mill.

They located their barrel pump and time cycle control in the motor room, and run a ½" pipe loop line to the housing on the floor level, suitably protected. Metering valves are located at the base of the housings near the bearings, and final connection to bearings by high pressure flexible hose with a union coupling at the bearing end for quick detachment when changing rolls.

The insulation of the pipes is not required; however, a small steam line laid near the loop line keeps the lubricant soft and easy to handle.

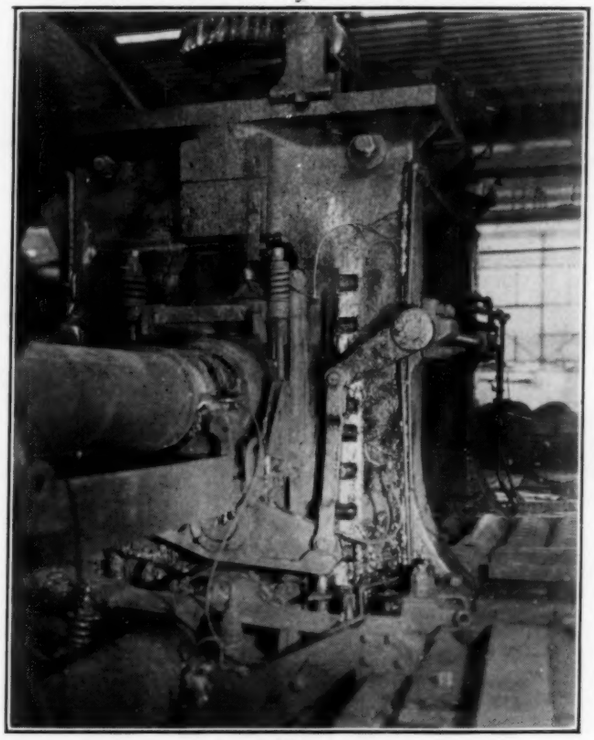


FIG. 1.

The control for this system is mounted in motor room on a switch-board panel, and you will note from the picture, it is rather large. Our new control is neatly packed in a 12"x18"x10" steel box, which can be conveniently mounted on any building column or wall.

They have tried to distribute the grease on the neck through wipers inserted between the neck and the housing with some degree of success, but the best method of distributing lubricant in a roll neck bearing, is to have the brasses or bearings drilled in such a way that the hole through the center of the brass leading directly to the collar, and one or two other long deep grooves to be provided on each side of the bearing for distribution of the lubricant to the neck proper. This has been found to be the most satisfactory.

The system is started by operating the toggle switch mounted on the Automatic cycle repeating time contractor. The length of cycle is set by a knob on the instrument, which moves the adjustable cycle contactor to any position within the dial range, and the timer automatically continues repeating.

At the length of each cycle a contact is made, energizing a magnetic starter switch which starts the barrel pump motors; lubricant is moved around one end of the loop to the first metering valve, automatically moving the dumb bell sliding valve and floating piston to the far end of the cylinder. The lubricant ahead of the piston is forced into the bearing at a pressure equal to the resistance the bearing offers.

When piston has come to a stop at far end of cylinder, it automatically closes port to the bearing and opens a by-pass port which permits the lubricant to proceed to the next metering valve, and so on, in progressive order, until all bearings are lubricated.

After the last metering valve has operated and by-passed, the pressure moving the grease in the entire loop through all metering valves now operates the automatic reversing valve and indicator switch, stopping the motor.

On the last half of cycle, clock again starts motor and the lubricant is pumped through the loop in the opposite direction, moving the pistons in the metering valves again to the far end of the cylinder, and each valve discharging the metered amount of lubricant and reversing automatic valve indicator switch, stopping the motor same as before.

During all this operation, an amber light will flash at convenient locations, where it can be readily seen, showing men in charge that the system is functioning, and if extra shots of lubricant are desired between scheduled time cycles, push button switches may be located at convenient points, and operator can start as many cycles as he desires, by merely pushing a push switch with his finger which performs the same function as the timing clock.

In the event of empty barrel, and pump is not pumping lubricant, or a broken line, and the lubricant cannot make complete circuit through the automatic valve to shut off the motor, it will run until time held contact on the time clock, which will be set at fraction of a minute beyond the time it requires to complete one cycle, and will automatically stop pump motor, turning on a green distress light, and if necessary other instruments, such as bells or klaxons may be operated to attract attention.

In the event of a clogged bearing anywhere in the circuit, and creating excessive pressure above 2000 to 3000 lb. depending on how the circuit is set, the pressure switch will automatically turn on red light and shut off the motor.

The location of the clogged bearing can be quickly found by removing small plug provided on each metering valve, which will show if lubricant is passing that point.

The danger of clogged bearing with this system is very remote; the normal operating pressure on roll neck bearing is around 500 to 600 lbs. per square inch. Our system is designed for a maximum

of 3000 lbs. per square inch, giving an ample safety factor, and since lubricant is pumped past small mesh screen on the intake of the pump direct from clean barrel, chances of getting foreign matter into the line is remote, and in the event of babbitt wiping over and filling up the slot areas in the bearing, our high pressure is sufficient to keep lubricant grooves open.

It is just as logical to provide the steam lines near the loop lines carrying the lubricant and hot plate for the drum or electrical elements inserted into the drum near the intake of the pump.

The heat applied should keep the lubricant warm and free running and not too hot to cause separation in the event the mill is using low grade of greases that have a tendency to separate.

This System will handle lubricants that will settle to the bottom of a manufacturer's container and tend to seek its own level when warm.

The barrel pump is inserted into the manufacturer's barrel of lubricant, and pumps the lubricant direct from the bottom of the barrel into the system, entirely eliminating the handling of lubricant and chances of getting foreign abrasive matter into it.

The Pump is composed of three members. The cylinder is revolved, one revolution with each stroke of the piston, thus actuating as a revolving valve and eliminating all springs and ball checks normally found in pumping units. The entire pumping unit may be transferred from one barrel to another by two men manually, or hooks are provided for lifting by crane.

The saving of lubricant by application of our system to roll neck bearings largely depends upon conditions; however, in any condition, the lubricant alone will quickly pay for the entire installation. Well lubricated bearings will naturally decrease friction and afford a worth while saving in power, bearings, general maintenance and upkeep of equipment.

Our system will eliminate the human element entirely. It will always function on time and as often as you desire it to function, and since no men are required to operate it, safety hazard is entirely removed.

There should be a decided improvement in the product rolled due to the fact that bearings will last longer, maintaining the roll setting to gauge longer at less horse-power and cost.

Cleanliness with this system is apparent, and it will depend upon how much excess lubricant the operator forces into the bearings.

The application of our Lubricating System to any roll neck mill does not prevent the operator from using his old method of lubricating in case of extremely scored or bearing emergency.

By M. J. HELMES* and J. GUY GRIFFITH†

Lubricator Unit

The Bosch Forced-Feed Grease Lubricator is a self-contained unit comprising in the main two major parts, namely: A grease tank which holds the grease supply and integral thereto a cast iron base containing a pumping system. The latter consists of a multiple of pump units, each one of which furnishes the supply of grease required by the individual bearing.

It is operated in a positive mechanical manner, suitable for rotary or oscillating drive, directly hooked up to and actuated by a member of the rolling mill machinery, or it may be motor, driven.

The lubricant is delivered to the feed points with consistent flow against the different resistance pressures in the feed pipe lines and a minute adjustment of the quantity of the lubricant to be fed to the bearing to maintain the lubricating film is made possible.

Feed Resistance With Different Diameters of Feed Pipe, Temperature and Kind of Grease

Kind of Grease	Temperature °F	Feed Resistance in lbs. per sq. in. per foot of Feed Pipe Line. Outside Diameter .2362″	.3150″	.3750″	.5″
Grease #1	68	23.6	17.2	12.9	8.6
	32	34.4	23.6	17.2	12.9
	14	51.6	34.4	21.5	17.2
	— 4	77.4	43.	30.1	21.5
Grease #3	68	30.1	21.5	15.05	10.75
	32	47.3	30.1	21.5	15.05
	14	77.4	38.7	30.1	21.5
	— 4	107.5	55.9	38.7	30.1
Grease #5	68	43.	30.1	21.5	12.9
	32	77.4	47.3	25.8	17.2
	14	94.6	64.5	34.4	23.6

* United American Bosch Co., Springfield Mass.
†J. Guy Griffith Company, Pittsburgh, Pa.

The Greases used for these tests have the following characteristics:

	Penetration	Melting Point
Grease #1	260	195
Grease #3	200	200
Grease #5	120	200

Penetration or consistency is measured by the A.S.T.M. method D-217-27 T.

Rolling Mill Equipped With A Bosch Unit:

The details and special features of one of the first installations of a slabbing and roughing mill equipped with a Bosch Unit KP-6 and a Twin Unit are as follows:

The mills have 28″x84″ Face Rolls with 20″ diameter necks, and the bearings are 20″x16″. The three mills together with seven roughing mills are driven by a 1200 HP motor. The finishing line consists of nine mills, eight of which are 28″x84″ and one 28″ x60″ with 800-HP motor drive.

The Bosch Forced-Feed Grease Lubricator Unit is located close to the roll housing and hooked up and actuated direct by one of the spindles. The oscillation of the lubricator drive shaft lever is attained by means of an eccentric.

Copper tubing was used in the preliminary and temporary arrangement which afterwards was permanently replaced by 3/8″ steel pipes, paid down close to the mill train and no insulation is used. Advantage of a ditch running parallel to the mill housings was taken in laying the pipes, so that no additional protection was necessary.

The feeding of the lubricant is automatic; i.e., the bearings are lubricated when the mill starts and lubrication ceases when the mill stops. The Bosch Forced-Feed Grease Lubricator Unit is in operation on this particular mill for about six months.

The method of the distribution of the lubricant

on the necks and the location of the feed pipe terminal shows that the feed pipe of one outlet from the lubricator leads to the top brass and is bifurcated at the bearing so that the lubricant is fed to the carrier

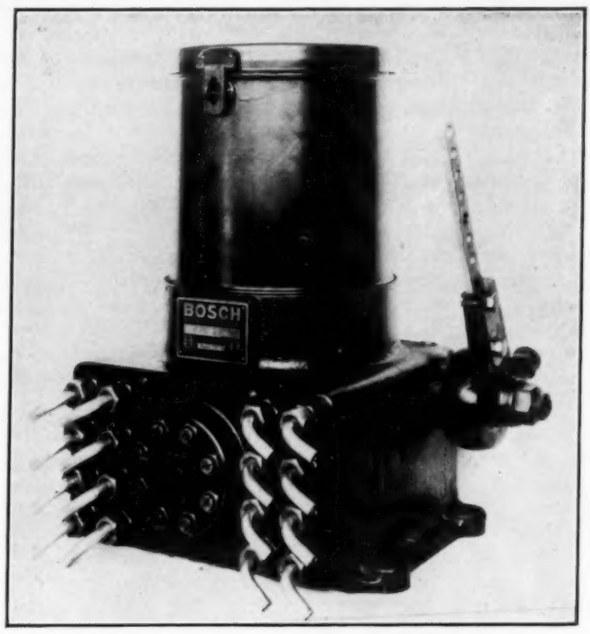


FIG. 1.

brass and the top brass. The feed tubing of a second outlet leads to the bottom brass of the bottom roll. This is typical of all the mills in line. Chicago Universal Quick Detachable Couplings provide easy disconnection of the flexible tubing.

The amount of grease fed to the bearing is controlled by simply turning the adjusting screws of the lubricator unit with a screw driver, thereby changing the stroke of the working plunger of the pump units.

The grease is put direct from the manufacturers container into the grease tank of our grease lubricator unit which can be locked.

Our lubricator unit is guaranteed to work effectively against a resistance pressure of 1500 lbs. per square inch under continuous service conditions, with consistent flow, and will handle any grease that is workable under a "kneading" effect. High resistance pressures are built up in the feed pipes due to low temperatures and heavy stiff greases used.

Power savings were estimated—definite figures, however, are not available—the author therefore refrains from citing same.

The economies in lubricant attained by the use of our unit is exemplified in the low consumption of grease, which, over a period of four months, showed an average of 0.007 pounds per hour per bearing. The grease used is of a relatively stiff consistency and carries a considerable graphitic content.

Through the installation of our units, an elimination of 24 man hours per day is attained, representing approximately $12.00 per day in labor. It has been a practice at this specific plant to compensate for the wear of the brasses by setting in shims, and this labor was performed about every three weeks. On the mills equipped with our lubricator unit, no shimming of the brasses was necessary over this period of three to four months.

In the opinion of those who operate the mills previously described, the simple, neat and efficient installation of our forced-feed grease lubricator unit exemplifies a decided step forward in the Art of Lubrication.

Discussion

Devices and Appliances for Steel Mill Roll Neck Lubrication

Discussed by

J. A. Clauss, Chief Engineer, Great Lakes Steel Corporation, Ecorse, Mich.

J. H. Van Campen, Chief Engineer, Youngstown District, Republic Steel Corporation, Youngstown, O.

J. D. Tinsman, Special Mechanic, Jones & Laughlin Steel Corporation, Aliquippa, Pa.

H. A. Mentall, General Superintendent, Thomas Steel Co., Warren, Ohio.

J. L. Miller, Steam Engineer, Carnegie Steel Co., Youngstown, Ohio.

C. R. Hand, Lubrication Engineer, Bethlehem Steel Co., Sparrows Point, Md.

A. J. Jennings, Vice President, Lubrication Devices, Inc., Battle Creek, Mich.

Thomas Watson, Trabon Lubricating Equipment Co., Cleveland, Ohio.

H. J. Anderson, Engineer, Hills McCanna Co., Chicago, Ill.

G. P. Dempler, Trabon Lubricating Equipment Co., Pittsburgh, Pa.

W. P. Sheehy, Maintenance Engineer, B. F. Goodrich Co., Akron, Ohio.

C. A. Fine, Industrial Sales Department, Alemite Corporation, Chicago, Ill.

G. T. Hollett, Steam Engineer, Illinois Steel Co., So. Chicago, Ill.

J. A. Clauss: I am very much interested in the problem we are discussing at this meeting. As everybody knows, at Detroit we have recently installed a great deal of new equipment and I will frankly say that we have not installed any of these devices on this equipment, though it was seriously considered, and all of the equipment is so designed that they could be added any time.

About eighteen months ago, when we started to order this equipment, these devices were rather new, and the fact that they were not installed does not mean that we were not interested.

We had enough problems on our hands without injecting more by pioneering in the development of lubricating devices. The improvement in these devices has been remarkable in the past year; had we installed them eighteen months ago they would not be obsolete.

We are very much interested in this Lubricating problem; in fact, enough so that I brought our General Master Mechanic along with me to this meeting. He naturally is very much interested in the proper installation of automatic lubrication on the immense amount of machinery entrusted to his care.

As I mentioned sometime ago, there is a great deal of literature the Chief Engineer is getting practically every day, and various salesmen are clamoring at our doors for a hearing which I think they are entitled to, and when they get a hearing they ought to have our undivided attention.

I will say from my personal contact with a number of the speakers we have here today that they have always been willing to discuss our problems of lubrication, even though they knew we were not installing automatic lubrication for greasing our equipment, but were confining our efforts to the standard type of oil circulating systems.

In these devices shown and discussed today I don't think we have everything the best that we might possibly have, but at least we are doing something to better lubricate our high-speed mill equipment.

The proper lubrication of the Blooming Mill is also receiving considerable attention.

While the past year has seen a great advancement in automatic lubrication, I believe as a result of this meeting and the formation of your Lubricating Committee there will be further advancement made and a more general application of automatic lubricating devices.

J. H. Van Campen: I don't know that I have any questions to ask; I think that we have heard some very interesting papers this afternoon. I believe that what has brought this subject up is due to the fact that a considerable amount has been done in the application of anti-friction bearings and the reduction of power pertaining thereto, and the lubrication of these bearings, but there are so many plain bearings throughout our plants where it is extremely hard to substitute anti-friction bearings; therefore, in order to prolong the life of these plain bearings and at the same time do all in our power to reduce power losses, a considerable amount of thought has been given to the proper and systematic lubrication of such plain bearings. I believe that there is a very wide field on this side of the picture.

It is certainly pleasing to see this activity as it is only in its infancy and we can hopefully look forward to a large amount of work and information from the manufacturers of such equipment.

J. D. Tinsman: There is not much I can add to the talks that have been given. The illustrations and discussions on the subjects have been brought out very well. There is much more to be developed along these lines in the next two or three years. At this time it would be well for each of us to think about lubrication for roll necks, also other mill machinery, and in a few years, believe there will be a great savings in power, maintenance and upkeep of equipment.

H. A. Mentall: Mr. Chairman, our company manufactures cold rolled strip steel. I have seen the manufacture of this particular product rolled from a maximum width of three inches to a present maximum width of 42 inches. In the old days of cold rolling steel we used babbitt bearings. The percentage of reduction was very very small. Today the various rolling machine manufacturers of equipment are producing a type of machine whereby we are able to roll at very high speeds, and as a result we have, as Mr. Van Campen said, anti-friction bearings. Unfortunately a great many manufacturers have the old two-high type of mills with either bronze or babbitt bearings of some kind. In order to keep our heads above water we have had to increase rolling speed for a larger production. In an ordinary two-high mill it will average about 125 feet per minute. In the old days we could only get 50 to 70 feet per minute, and now in the roller bearing type of mill we can roll 400 to 500 feet per minute, and in some types of mill 1100 feet per minute.

But these grease salesmen and various fellows that have to do with lubrication visit us as plant managers sometimes to such an extent that they become a pest. However, they are the best friends we have. We have in our plant at the present time a system that has been presented to you today, which I believe will tend to solve our problems of increasing efficiency and decreasing friction on the necks, eliminating checking roll necks, and consequently decreasing the cost of lubrication, and also bettering our product.

To those gentlemen who are not familiar with cold rolling I might say that I believe the friction is greater and causes more trouble than in the hot mills. If we are depending on the rollers to pack the neck with greases of various kinds that have been sold, while any packing is good for a short time, and you have your lubrication, yet, in a little while the roll neck becomes bare because a track has been worn in the packing. Our first experiment was with a hand-operated lubricating device, and it was found that a diminution of 75 amperes was made as long as grease was applied to the neck. So I think all of you manufacturers are to be highly commended on the steps you have taken in eliminating the trouble of the mill men—we cannot praise you too highly. It is only a question of a short time when you will be able to sell the owner on the idea that your installation will surely pay for itself.

J. L. Miller: This subject of roll neck lubrication has been of considerable interest to us in the Youngstown district, primarily we have been interested in the lubrication of roll necks on high speed mills. There has been very little said here in connection with the lubrication of the high speed mill.

About three years ago we were starting into the development of a new high speed mill. We experimented in conjunction with the anti-friction bearing companies with a view to possibly putting in an anti-friction bearing installation in this mill finishing as high as 3000 feet per minute. As Mr. Van Campen has said we were all so interested in the anti-friction bearing that we were trying to get away from the solid bearing, if at all practical.

We decided, however, to stick to the solid bearing and endeavor to lubricate the roll necks under a pressure feed. As a result of this we developed and

have had installed since about November, 1928, a roll neck lubricating outfit for the last three stands of our 12" continuous mill having a finishing speed of about 1600 feet per minute. The rolls on these stands have 9" necks. We have increased the life of the brasses on these three stands from 2.3 to 3.5 times, with a reduction in the amount of lubricant of about 50 per cent.

Our equipment differs from anything we have been shown here today in that we have a positive supply of grease to each bearing by means of a number of parallel arranged pumps. The pumps are driven, through a reduction drive, by a variable speed D.C. motor, permitting a wide variation of the feed by varying the speed of the motor. The power required to put a medium, tallow compound, roll neck grease through the lines ranging from about 16 feet to 45 feet in length, the distances of the nearest and farthest stand, amounts to about .25 to .3 HP.

The data gained in our preliminary tests for the determination of pressure drops through various sizes of pipe and fittings at different rates of flow and for different grades of greases have been found to be very accurate in the other installations of this equipment which we have made in the Youngstown district.

The lubrication of table roll bearings and bearings carrying low unit pressures is a problem quite different from that of the lubrication of high speed surfaces and bearings carrying high unit pressures and exposed to severe shock loads.

C. R. Hand: I have enjoyed the papers thoroughly. They certainly covered everything in this line. But there is one question in my mind, and that is the matter of attaching a hose to the bearings. There is quite a little bit to be said in that regard for this reason. If you put something in there that takes fifteen minutes to get loose, a mill wrench is going to be used to get it loose, and the millwright is going to be necessary to put it back on. Mr. Anderson spoke of the Chicago Automatic Coupling, and I don't think anybody else told us what form of coupling they had. I would like to have something on that.

A. J. Jennings: I would like to say that we have experimented with the so-called quick coupling, and we have finally boiled it down to a standard union having a triple thread; in other words standard pipe union, one and a quarter turns takes the looseness out—with three threads on it. Our experience has been with the so-called pneumatic couplings, you can disconnect them as the manufacturer intends, but if you get them covered with grease, as Mr. Hand says, you will have to work at them for a quarter of an hour.

Thos. Watson: We have a union which has a very large connection with it made in the form of a gun neck, and the way it is operated is by hitting it with a hammer. No special equipment or tools are necessary; all you do is hit it and it is gone. It hasn't any hexagonal or octagonal or anything of that kind on it—it is inch and a half or two inches across the width.

H. J. Anderson: The experience that I have had while I was employed in the Wisconsin steel mill, I took an ordinary air hose connection, and we machined it down to fit inside of an ordinary air hose.

C. R. Hand: What do you mean by an ordinary air hose connection? I have seen dozens of them.

H. J. Anderson: I don't know just which one by name; you take about a quarter turn.

C. R. Hand: Is it Chicago Pneumatic or Cleveland Tool and Die?

H. J. Anderson: Cleveland Tool and Die, and we machine that and put a thread on it and wire it to the hose to keep it from slipping off, and we have had very good results for quick opening.

C. R. Hand: I think that is a point that should be discussed particularly, because I know our men that are in the plant that I am in, object to anything that takes much time to get off. We have practically adopted the automatic coupling in the matter of grease connection to the bearing. We have been getting good success with it—it is merely a matter of lifting it up to take it off. However, there are one or two points that must get attention, otherwise we have had no trouble with that type of fitting.

There is one other point that I would like to bring out, and that is the matter of grooving the bearings. You take the reversing motor, in the plant where I am located, and without exception they have no grooves in the bottom bearing. They have a free bore or off-center bore on both sides of the bearing, whether they are reversing or non-reversing motor. The plant at Sparrows Point is to adopt that system to the other bearings throughout the plant, meaning by that, pinion bearings or other bearings at both top and bottom.

G. P. Dempler: We have found in some cases where there is lots of bad water like that we have here in Pittsburgh has ruined a bearing. Steel pipe connections readily corrode and break off when you don't want them to. Some of our customers have, and we highly recommend going to brass and copper pipe at the end of your system. Now, as some gentleman here have been using ordinary rubber hose for connections, but ordinary rubber hose don't seem to last very long. We are told by the rubber manufacturer today that Royal Resistance hose will stand a lot of lubrication and won't deteriorate. Some of them have woven wire inside of them and they will stand very high pressure.

W. P. Sheehy: Mr. Chairman, if you will forgive the expression, I feel very much like the proverbial lamb among wolves today, because I represent the manufacture of another product than that which most of you people do, but however, the equipment that we have in the rubber industry is after all quite similar to that which you find in the steel mills, and I just want to add this, that we have used for the past four or five years certain apparatus for automatic lubrication of our calenders and mills. particularly the calenders. I think perhaps most of you are familiar with that type of equipment.

I don't wish to try to add anything more to the discussion, which has been intensely interesting to me, but I want to express my appreciation for the invitation to come down here from Akron today to listen in on these papers, and I know that the next few months or few years you are going to see the

automatic—we are intensely interested in the application of automatic lubrication devices. I thank you very much for this invitation and this opportunity to speak.

C. A. Fine: Mr. Chairman and gentlemen, I hope that you will excuse me for assuming to come to your meeting without a formal paper, but my superior got me down about a week ago and I have been in the hospital, and this is my first day out.

And I also think that possibly the worthy gentlemen who have talked with you have pretty well described some mighty fine systems of roll neck lubrication, and I am not going to attempt to tell you any further about a description of a system, except to say that we have been working for a great many years in the development of lubrication appliances.

We recognized at the very start certain limitations on the handling of grease. Those ideas are very valuable to us. You can assume in the handling of grease at the very start that none of the things that you might use in the calculation of the handling of oil, water, steam or similar liquids will apply to the handling of grease. Grease as we see it is a combination of a liquid, a gas and a solid, and it has some of the bad elements of all of them. For instance, it is impossible to set up a given orifice against grease to give it pressure against it and be at all assured that the flow of grease through the orifice will be all that you calculate. If you have two orifices in the system equally distant from the inlet, your results will not remain the same.

Furthermore, grease is slightly compressive where oil is not, so one of the first things that you can take into consideration is the fact that you cannot split grease; you have got to run it into individual lines to the bearing that you want to put it in, and measure the amount that you want to put in there, if you want any degree of exactitude.

In the course of development of a system that would be suitable for roll neck lubrication we have tried to keep within the principles that seem to us to be correct. In the first place a small, compact machine with few leads that could be located close to the bearings so that an excess of piping would not be necessary.

In the second place, the means of putting the lubrication into the container must be simple. In doing this we have simply put a handy lid on it, and gentlemen, we don't care whether you use lubricant as light as water or whether it is up to what is commonly known as No. 5½ or No. 6 tallow grease with graphite that may have stood out in the weather and had a chance to become solid over a considerable period of time—that is your problem, and you know what you want to do. All we can do is supply a means of handling it. You can shovel it in, dump it in or pour it in, that's all, and you can lift the lid at any time and see what is in there, and you can apply new lubrication at any time.

Suffice it to say that after it is in the compressor, that very simply we take out every drop of air so that no air can enter and bind your supply line.

We then force the grease into the lines, and can apply 8000 pounds pressure. When I say 8000 pounds pressure, understand me that I mean this, that that is the maximum amount of pressure that the pumps will deliver to the pipe line. The amount that you actually apply is the amount necessary to overcome the friction of the pipe line and bearing.

We can supply the lubricant in amounts of from one-quarter ounce to seven pounds per hour per outlet. We can change the speed of piston from one to another at 16 to 1; in other words one outlet can get sixteen times as much lubricant as the next. We can deliver lubricant into your bearings at the rate of one stroke of the pump every three minutes, or we can speed up the pump where it will deliver 27 strokes per minute, and gentlemen, the only mechanical appliance, or the only necessary connection is 40 pounds of air, nothing else.

Briefly that is the system as we have it outlined. The units are small; it will take a space of 35 inches high, 15¼ inches wide and 27 inches long. These units have been developed and it has been in constant service day and night in our own plants as a matter of test for over two years. We are newcomers in the field insofar as having applied these devices to rolling mills is concerned. The first pair of these devices will most likely go into service in the Chicago area. What the result will be I make no predictions, no promises. We have built it the best we know how, as simply as possible.

I have made no pretense of telling you gentlemen how to grease your bearings, because I believe you know. We have built up a system as scientific as our experience dictates to us, and let it go at that. This roll neck game is too new, and there are too many things to learn in the future for me to stand up on this platform at this time to make any predictions.

There are other parts of the rolling mill besides the necks that I believe you gentlemen are earnestly considering as having a great deal to do with the performance of the entire mill, with its upkeep and life. I would like to cite you for a moment, if you will allow me, a performance that is on a 10-inch Merchant mill in the Chicago area, to which we have mounted a unit that we developed a year ago, in which you dump an entire barrel of lubricant and which operates on 90 pounds of air pressure. The installation takes care of the roll table, the cooling table. The roll table is 600 feet long.

This installation has been in operation for several months and is giving complete satisfaction. Now gentlemen, just one more word and I am through. About four or five years ago it would have been impossible to get a group of gentlemen such as are in this room together to discuss a lubrication problem. We have been in the lubrication business a long time, and the growing need of lubrication is in our own minds, it has always been with us, we are simply becoming conscious of it. I hope that this is the first of a series of meetings where these problems can be brought out and discussed, and I will assure you that our corporation deem it a privilege to come to you at any time and discuss these matters, and I want to take this opportunity to thank Mr. Pecu and the gentlemen assembled here for having invited me.

G. T. Hollett: I enjoyed these papers very much. We are completing a program where it was necessary for us to investigate lubricating work very thoroughly. If we had had an opportunity to listen to these papers two years ago we would have appreciated it very much.

There was a point brought up that I think is worth going into very thoroughly. The lubricating equipment may deliver the lubricant to the bearings but if it is not applied there properly it is of no avail. The design of the grease grooves in the bearings is as important as the design of the equipment that delivers the grease to the bearing. It is not satisfactory to apply the grease on the shaft or roll neck and expect to pull the grease around the shaft and into the bearing.

The lubricating work of roll necks is just in its infancy. There is only a very small portion of the roll necks that are properly lubricated. We have one system of roll neck lubrication that has been in operation something over a year and the bearing life has been increased on this 40" Blooming Mill from an average of six weeks to an average of approximately six months. The adjustment of the mill is also very much less than formerly. We are pleased with this type of lubrication and have recently installed similar equipment on four of the new mills now being constructed.

Items of Interest

PERSONNEL CHANGES

Stanley McKee, formerly chief engineer of the Republic Steel Corporation, has become associated with the Youngstown Sheet and Tube Company as a special engineer, and is located in the Stambaugh Building, Youngstown.

D. M. Stackhouse, formerly vice president of the Cambria Iron Company, Johnstown, Pa., a subsidiary of the Bethlehem Steel Company, has been elected president of the Cambria Iron Company, succeeding the late R. Francis Wood.

John D. Tyson, formerly assistant metallurgical engineer of the Standard Steel Works Company, has been appointed chief metallurgist.

Roy M. Hurst has been appointed Pittsburgh district manager of the Shepard Niles Crane and Hoist Corporation. His office in Pittsburgh has been moved to the Grant Building. Frank J. Kinney, who has represented this company for many years, will be associated with Mr. Hurst. Mr. Hurst has been with the Shepard Niles Company for many years and until recently was in its New York office. Harry A. Baugh has been appointed district sales manager in Cleveland for the Shepard Niles Company, whose office in that city has been moved to 1433 East Twelfth Street. Mr. Baugh was for many years district manager of the company's Pittsburgh office and more recently has been in the Chicago office.

Perin and Marshall, consulting engineers, 11 West Forty-second street, New York, have been dissolved by mutual consent. The company was formed in 1914 and consisted of Charles Page Perin, Stewart M. Marshall and Frank L. Estep. Perin Engineering Company, Incorporated, has been formed, with offices at the same address. Mr. Perin will be president, Mr. Estep, vice president and chief engineer, and David J. Ogilvie, secretary and treasurer.

Rockbestos Products Corporation, New Haven, Conn., announces the appointment of Malcolm T. Ritchie as New England Territory salesman, the addition to its Pittsburgh sales office of Carleton W. Fletcher, formerly of the main office, and the addition of Philip O. Weston to the home office sales promotion staff.

Mr. John W. Blackford, for the past eight years with the Torrington Company and for the last two years manager of the Detroit office of the above company, has joined the sales organization of Norma-Hoffmann Bearings Corporation, Stamford, Conn.

L. M. Dunning has been advanced to a sales representative of the Chicago office, and Herbert A. Holmes has been advanced to a sales representative of the Pittsburgh office of The Reliance Electric and Engineering Company, Cleveland, manufacturers of alternating current and direct current motors.

Bradley Stoughton, widely known as author, educator and able engineer, and since 1923 Professor of Metallurgy at Lehigh University, has been appointed Consulting Metallurgist of Standard Steel Works Company of Burnham, Pa.

Harry C. Cronk has become associated with the Freyn Engineering Company and becomes a part of the group of Freyn engineers located at Leningrad, U. S. S. R. For the past three years, Mr. Cronk has been electrical engineer of the Tata Iron and Steel Company at Jamshedpur, India. Prior to that time he was, for many years, electrical engineer of the McKinney Steel Company of Cleveland. Vance Cronk, a brother of Harry Cronk, has been associated with the Leningrad group of Freyn engineers for the past two years.

WITH THE MANUFACTURERS

ELECTRIC TRACK SWITCH HEATERS

The Electric Service Supplies Company, Philadelphia, Pa., announce the new track switch heater, which is of interest to steel plants who have trouble melting away ice and snow on railroad tracks switches. The Electric Service Supplies Company will be glad to furnish information in connection with this new switch.

DIEFORM COMPRESSION FITTINGS AND TUBINGS

The Bailey Meter Company, Cleveland, Ohio, announces a very interesting bulletin No. 113, covering Dieform Compression Fittings and Tubings. Bailey Meter Company will be glad to furnish this bulletin upon request.

TRIPLEX RECORDING AMMETER

The Bristol Company, manufacturers of Bristol Recording Instruments, at Waterbury, Conn., announces a new bulletin No. 104, which describes their

recording ammeter. A copy of this bulletin will be furnished upon request.

BOOKLET

The National Carbon Company, Incorporated, Carbon Sales Division, Cleveland, Ohio, announces the publication of a new booklet entitled "Behind the Pyramids." This booklet tells a very interesting story of the manufacture of carbon brushes. The National Carbon Company would be glad to furnish this booklet upon request.

BULLETIN—POWER PLANT EQUIPMENT

The Elliott Company, Pittsburgh, Pa., with works and sales-headquarters at Jeannette and Ridgway, Pa., has produced an attractive bulletin, 24 pages and cover, entitled "Power Plant Equipment." This bulletin covers the entire Elliott line of power equipment, devoting one page to a product, and including the tube cleaners manufactured by its associates, the Liberty Manufacturing Company and Lagonda Manufacturing Company. Products briefly shown and described in the bulletin include: turbine and engine-generator units, motors and motor-generators, centrifugal blowers, condensers, ejectors, deaerators, feed-water heaters, desuperheaters, strainers and power accessories.

FLOODLIGHT

A 100-watt general-utility floodlight projector, the Novalux Handy Floodlight, has been announced by the General Electric Company. Much smaller and less expensive than the usual projectors, the new unit is expected to find new fields of application where light requirements do not necessitate the larger standard floodlighting units.

The projector, weighing less than three pounds and measuring less than nine inches wide, 10 inches deep and 13 inches high with its supporting stand, is built for a 100-watt inside-frosted general-service incandescent lamp with 4⅜ inch light center and medium screw base.

The new unit is composed of a sheet aluminum combination casing and reflector, pressed together with a separately drawn socket-supporting cap over a supporting ring. The socket support, casing-reflector and ring are made substantially integral by the pressing and beading operation. The casing is polished inside, forming the specular surface for reflecting purposes.

The front lens, 8 inches in diameter and of heat-resisting, clear, convex glass, is clamped against a gasket fitting in a groove in the reflector, a rolled split clamping ring with non-losable clamp screw at the bottom engaging two clamp castings riveted to the ring.

A rubber-covered twin-conductor lamp cord is woven through a rubber bushing affixed to the socket-supporting cap to prevent entrance of moisture and abrasion of the cord.

The support for the projector is of cadmium-plated steel. Vertical and horizontal adjustments are obtained with wing nuts in the swivel support and base. The projector is finished in dark green baking enamel for the base, swivel support and casing. The clamping ring is aluminum lacquer sprayed, and the clamping bolts and wing nuts are cadmium plated.

NEW MAGNETIC CONTROLLER

The Ohio Electric Manufacturing Company at Cleveland, Ohio, announces a New Magnetic Controller. This new controller may be had with push button or lever type master for any size magnet, including the largest size.

ARC WELDER EQUIPPED WITH FLANGED WHEELS

A gas-engine driven welding set equipped with flanged wheels for track service is offered by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. This "Flexarc" welder is a 2000 ampere, single operator, self-contained unit, especially suitable for construction work beyond the reach of power lines. The model is available for service on railroad tracks or in mines.

A NEW TYPE OF DRY QUENCHING UNIT

For the Dry Quenching of Coke in Small and Medium Sized Gas Plants

An improved and entirely new type of unit for the dry quenching of coke has been developed by the Dry Quenching Equipment Corporation, New York City, for use in coal gas plants where the quantity of coke produced per day is relatively small.

In the dry quenching of coke, a volume of inert gas is forced through the bed of hot coke, removing the sensible heat. The heated gas is then passed through a waste heat boiler which reclaims the heat removed from the coke. Thus, a source of steam supply is made available at very low cost, an improvement in the quality of the coke is obtained, and the many disadvantages of water quenching are eliminated.

GREAT LAKES STEEL ORDERS SPECIAL LOCOMOTIVES

Two 70 ton 300 h.p. oil-electric switching locomotives have been ordered from the Westinghouse Electric and Manufacturing Company of East Pittsburgh by the Great Lakes Steel Corporation for use in their plant at Detroit, Michigan.

These oil-electric locomotives are unique in design. Since they will be called upon to perform such services as the handling of ladles of molten metal, ingot buggies, etc., in addition to the usual switching and weighing operations, they must be protected from the heat to which they will be subjected. Inside and out they will be painted with a special heat resisting paint. The windows, exceptionally large and low, will be glazed with a special glass to withstand a temperature of boiling water. Safety steps will be illuminated. Lighted bulls'-eyes on the front and rear of the cab will indicate at once whether the engineer is running the locomotive from the right or left side. A similar oil-electric switching locomotive is now in successful operation at the Butler plant of the American Rolling Mill Company.

TREATISE ON LEATHER BELTING

A most interesting book entitled "Treatise on Leather Belting" by George B. Haves, Professor of Advanced Machine Designing of Massachusetts Institute of Technology, is now off the press and ready for distribution. Write the Technical Composition Company at Cambridge, Mass.

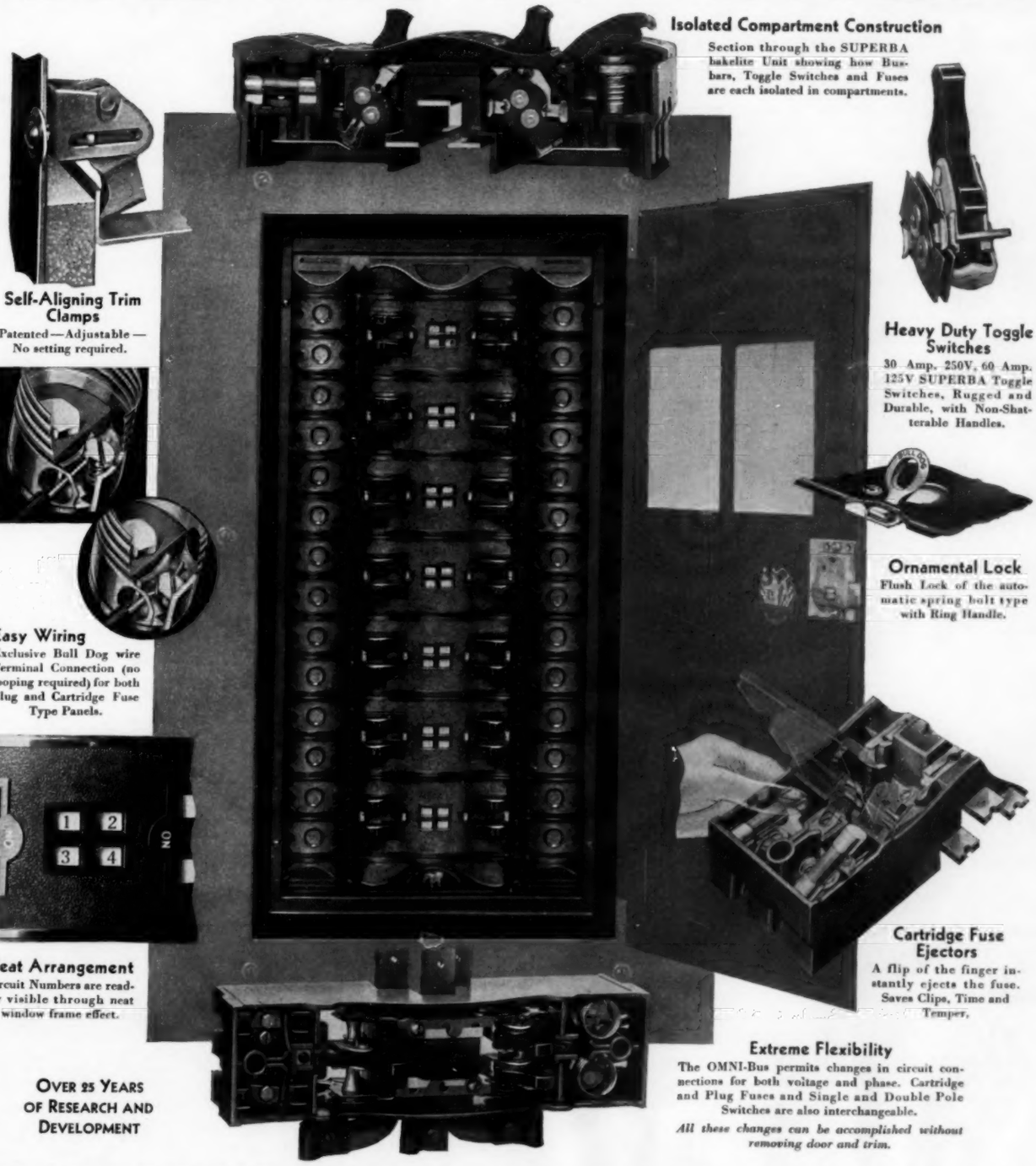
(Continued on page 198)

As Good as It Looks

Setting a new standard of design, the Bull Dog Superba Panel combines attractive appearance with a measure of utility and flexibility never before attained in panel construction.

Write for Bulletin

BULL DOG *SUPERBA*



Isolated Compartment Construction
Section through the SUPERBA bakelite Unit showing how Busbars, Toggle Switches and Fuses are each isolated in compartments.

Self-Aligning Trim Clamps
Patented—Adjustable—No setting required.

Heavy Duty Toggle Switches
30 Amp. 250V, 60 Amp. 125V SUPERBA Toggle Switches, Rugged and Durable, with Non-Shatterable Handles.

Ornamental Lock
Flush Lock of the automatic spring bolt type with Ring Handle.

Easy Wiring
Exclusive Bull Dog wire Terminal Connection (no looping required) for both Plug and Cartridge Fuse Type Panels.

Neat Arrangement
Circuit Numbers are readily visible through neat window frame effect.

Cartridge Fuse Ejectors
A flip of the finger instantly ejects the fuse. Saves Clips, Time and Temper.

Extreme Flexibility
The OMNI-Bus permits changes in circuit connections for both voltage and phase. Cartridge and Plug Fuses and Single and Double Pole Switches are also interchangeable.
All these changes can be accomplished without removing door and trim.

OVER 25 YEARS OF RESEARCH AND DEVELOPMENT

BULL DOG ELECTRIC PRODUCTS CO., DETROIT, MICH.—Bull Dog Electric Products of Canada, Ltd., Toronto, Ont.

FRACTIONAL HORSE-POWER MOTORS

Century Electric Company, of St. Louis, Missouri, announces a new line of fractional horse power motors having mounting dimensions interchangeable —in Repulsion Start Induction Single Phase, Split Phase Single Phase, Squirrel Cage Induction Three Phase, and DC types.

The bearing brackets of this design offer unusual protection against falling objects, dirt, or dripping water. These motors have rolled steel frames, welded steel feet, slotted for belt adjustment, and bearings machined from phosphor bronze castings. They are equipped with the Century Wool Yarn System of Lubrication.

IMPROVED MECHANICAL DRIVE TURBINE

Elliott Company, Jeannette, Pa., announces a new and improved mechanical drive turbine. This machine incorporates in its design many features of larger turbines for generator drive, such as horizontally split casing, steam and exhaust connections in lower half of casing, stiff shaft rotor—balanced both statically and dynamically, a three-weight governor with all sliding friction eliminated which insures quick response to load changes, emergency overspeed governor separate and distinct from the constant speed governor, each governor actuating its own valve, supports providing for both axial and lateral expansion.

This turbine, called the Type AY, is for a size range from 5 to 60 h.p. When lagged, and built with cast steel casing and steam chest, it is suitable for operation with 400 lbs, steam pressure and 700° temperature.

It is a single-stage turbine, the rotor having either two or three bucket wheels depending upon conditions.

ONE-UNIT MOTOR-GENERATOR SET

The Reliance Electric and Engineering Company, 1088 Ivanhoe Road, Cleveland, Ohio, manufacturers of alternating-current and direct-current motors has developed a new one-unit motor-generator set for ratings of one to five kilowatts.

In these sets the usual alternating-current motor and direct-current generator are combined into a single unit, requiring only two bearings—one at each end. The induction-motor rotor and direct-current armature are mounted on the same shaft.

This design provides a very rugged, compact construction which requires less space than with the two-unit sets. Because it is one unit the work of connecting and aligning individual units and attendant troubles are eliminated. The conduit outlets are large to make wiring very easy.

These Reliance Motor-generator sets can be furnished for operation on either two or three-phase circuits of any standard voltage or frequency and have an output rating of 1 to 5 k.w. at 125 or 250 volts. They may be obtained with either sleeve or ball bearings.

Tokuyama Steel Sheet Company of Tokuyama, Japan has purchased two Freyn-Design Electric Roll Heaters for installation at its sheet mills. This company purchased an initial installation of two roll heaters six months ago and this represents a repeat order, giving full equipment for its sheet mills.

Tennesse Coal, Iron and Railroad Company has purchased from Freyn Engineering Company one Freyn-Design Continuous Stockline Recorder for installation at one of its Ensley Blast Furnaces. This is the third Freyn-Design Stockline Recorder equipment purchased by this company.

OBITUARIES

William Gray Clyde, formerly president of the Carnegie Steel Company, Pittsburgh, and for many years one of the outstanding figures in the steel industry, died at his home in Pittsburgh on March 23. His death was the culmination of an illness which began in 1928, and which forced him to relinquish active duties in the Carnegie company on August 31, 1930. He entered the steel industry with the Wellman Steel and Iron Company, Thurlow, Pa., where he served as superintendent of plate mills. Subsequently he went to the Illinois Steel Company, South Chicago, in a similar capacity, where he remained for six years. Mr. Clyde then left the Illinois company to become sales manager at Philadelphia for the American Steel Hoop Company, remaining until that company was absorbed by the Carnegie Steel Company. In 1902 he was made sales representative of the Carnegie company at Cleveland, and in 1905 went to Pittsburgh as assistant general manager of sales. He was elected a director, and vice president and general manager of sales for the Carnegie company in 1918, and became president on October 30, 1925.

George R. Metcalf, Sr., for many years president of the Erie Malleable Iron Company, Erie, Pa., and for the past three years chairman of the board, died suddenly on March 23. He was a pioneer in the malleable iron industry.

David Meyers, assistant superintendent of Illinois Steel Company, Chicago, died recently.

Charles F. Morgan, assistant treasurer, comptroller and a director of Morgan Construction Company, Worcester, Mass., died March 3.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF
IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

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Editor—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Business Manager—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

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Association of Iron and Steel Electrical Engineers

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JOHN F. KELLY, Editor.

Sworn to and subscribed before me this 25th day of March, 1931.
A. L. McKEEVER, Notary Public.
(My commission expires January 26th, 1933.)